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For story, see page 490

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PAPERS

DRY PRESSING FOR MAXIMUM DENSITY*

By C. M. Dodd

Abstract

Grain sizing and proportioning of grog and clay mixes for dry pressing have been studied with reference to production of maximum density in unfired samples. The effect of the amount of moisture and the length of time of aging dry-press mixes on the green density of the resultant product are considered, and data are presented on the duration of (and variation in) the amount of pressure and their effect on density. A comparison is made of the maximum density resulting from regular methods with that produced by de-airing dry-press mixes and also by the use of endosmosis in dry-press mold-box lubrication.

I. Introduction

The term, maximum density, should be limited. In refractories, high true specific gravity can not always be considered as high density, because the porosity also may be high. Bulk density and apparent porosity are inversely proportional to each other. The percentage apparent porosity, resulting from forming firebrick mixes, is expressed in larger numbers than the bulk density; apparent porosity, therefore, will be used because variations can be detected more readily.

If all the grains of a mix had plane surfaces and were cubical or platelike, they could be arranged to give a product with few open voids. A dry-pressed mixture of large and small grains of various shapes, however, may or may not produce low apparent porosity, depending on the grain-size proportions, the shape of the grains and their natural porosity, the degree to which they are compressed, the shrinkage of individual grains in the compressed mix due to drying, and the amount of melting and gas generation that takes place in firing the ware.

Swain and Phelps[1] state that the bulk density of unfired bodies is not necessarily an index to the density of the fired product. Those bodies, however, which have maximum density before firing should give high density when fired.

II. Procedure

The methods of mixing, tempering, forming, and drying for all of the studies[2] from which data have

* Presented at the Thirty-Eighth Annual Meeting, American Ceramic Society, Columbus, Ohio, March, 1936 (Refractories Division). Revised paper received July 30, 1937.

[1] S. M. Swain and S. M. Phelps, "Proportioning Grain Size in Clay Refractories," *Jour. Amer. Ceram. Soc.*, **14** [12] 884–98 (1931); p. 897.

[2] Theses submitted in partial fulfillment of requirements for the degree of B.S. in Ceramic Engineering at the Missouri School of Mines and Metallurgy, Rolla, Mo.:

(*a*) H. W. Meyer, "Size and Shape of Clay Grains as Affected by Various Methods of Grinding" (1931).

(*b*) E. T. Harvey, "Effect of Various Methods of Grinding on Physical Properties of Unfired Dry-Press Brick" (1930).

(*c*) H. R. Herron and S. J. Tompach, "Transmission of Pressure in Dry Pressing of Typical Building Brick and Firebrick Mixes as Affected by Variation in Grog Size" (1931).

(*d*) G. A. Page and F. F. Netzeband, "Transmission of Pressure in Dry Pressing Typical Building Brick and Firebrick Mixes as Affected by Degree of Pressure, Physical Character of Mix Ingredient, and Moisture Content of the Mix" (1930).

(*e*) W. T. Kay, "Pressure Transmission and Green Strength of Clays as Affected by Time of Aging" (1932).

(*f*) R. E. Lee, "Pressure Transmission in Clays Affected by Time of Pressure Application" (1931).

been plotted are substantially the same; they have been described in a previous publication[3] or will be discussed here under the proper headings. Instead of using the average apparent porosity values of the two samples from the individual layers of the blocks, as shown in Fig. 1, the average apparent porosity of eight layers is taken as the apparent porosity of the block, and the maximum and minimum deviation from the average porosity, with the layers in which they occur, are indicated. The total variation within the block is shown in the tables.

NOTE: The previous experiments referred to[3] were carried out to determine the factors which would give the most uniform pressure transmission in the mix, from top to bottom of the blocks ($9^3/_4$ by $4^3/_4$ inches and approximately 8 inches deep), formed on a hydraulic dry press.

In comparing the apparent porosity values of these blocks, those factors which contribute to the most uniform pressure transmission are indicated by the lowest total variation in porosity.

III. Materials

Physical properties of the clays and mixes investigated vary greatly and cover practically the entire plasticity range used in the dry-press process of brickmaking.

TABLE I

GROG SIZE

(Average Apparent Porosity and Normal Deviation from the Average in Percentage)*

Grog size	−2.5-mesh (%)	−4-mesh (%)	−8-mesh (%)	−20-mesh (%)	−40-mesh (%)	−60-mesh (%)
(1) St. Louis surface clay (10-mesh)	29.13	29.53	30.31	31.41	32.48	35.13
	+0.82 (4)	+0.85 (4)	+1.02 (4)	+0.97 (4)	+1.41 (3)	+1.22 (5)
	−0.70 (1)	−1.05 (8)	−0.68 (8)	−1.26 (1)	−1.51 (8)	−1.02 (8)
	1.52 (*T*)	1.90 (*T*)	1.70 (*T*)	2.23 (*T*)	2.92 (*T*)	2.24 (*T*)
(2) North Mo. plastic clay (8-mesh)	23.34	23.07	23.62	25.08	26.43	28.24
	+1.38 (4)	+1.52 (4)	+1.51 (4)	+1.67 (8)	+1.33 (4)	+1.23 (4)
	−1.08 (7)	−0.94 (8)	−1.67 (8)	−1.48 (8)	−1.65 (7)	−1.63 (8)
	2.46 (*T*)	2.46 (*T*)	3.18 (*T*)	3.15 (*T*)	2.98 (*T*)	2.86 (*T*)
(3) Cheltenham clay (8-mesh)	21.88	24.44	22.90	24.29	26.54	26.80
	+0.79 (4)	+1.23 (4)	+1.01 (3)	+2.07 (4)	+2.33 (4)	+4.15 (4)
	−0.68 (7)	−1.12 (8)	−1.06 (1)	−1.68 (8)	−1.50 (8)	−1.79 (8)
	1.47 (*T*)	2.35 (*T*)	2.07 (*T*)	3.75 (*T*)	3.83 (*T*)	5.94 (*T*)
(4) North Mo. semiflint (8-mesh)	21.84	22.05	22.15	25.12	26.18	26.26
	+0.58 (5)	+1.32 (4)	+1.30 (4)	+1.19 (4)	+1.60 (4)	+1.59 (3)
	−0.86 (8)	−1.11 (8)	−1.33 (8)	−1.53 (8)	−1.16 (8)	−1.25 (7)
	1.44 (*T*)	2.43 (*T*)	2.63 (*T*)	2.72 (*T*)	2.76 (*T*)	2.84 (*T*)

Mix composition: grog 30%, clay 70% + 8% moisture (dry basis).
Forming pressure: 500 lb./sq. in.

* The number in parentheses following the normal deviation from the average apparent porosity indicates the layer in which the deviation occurs; the percentage followed by *T*, the total deviation.

The materials used in the mixes were (1) St. Louis surface clay (loess), (2) Cheltenham clay (plastic), (3) north Missouri plastic clay (plastic), (4) north Missouri semiflint clay (semiplastic), (5) No. 1 Missouri flint clay (nonplastic), and (6) firebrick grog (nonplastic).

NOTE: The effect of dry pan, rolls, ball mill, wet pan, and disintegrator reduction on shape of grain produced and the effect of grain shape on dry-pressed mixes were studied by Meyer[2(a)] and Harvey,[2(b)] who concluded that the grinding method does not produce enough variation in the shape of grain to produce any definite effect on the apparent porosity of the dry-pressed product. Therefore the data which they gathered are not presented.

IV. Clay and Grog Proportioning

The results of this investigation have been published[4] and only a brief summary is presented.

(*g*) W. R. Powell, "Effect of Occluded Air in Dry-Press Mixes" (1930).
(*h*) O. W. Kamper, "Effect of Electrical Lubrication on the Transmission of Pressure in Dry-Pressed Bodies" (1935).
(*i*) C. M. Dodd, "Effect of Grain Size and Grain-Size Proportions on Pressure Transmission in Dry Pressing" (1932); unpublished data.
(*j*) C. M. Dodd and M. E. Holmes, "Study of Effect of Grog on Pressure Transmission in Dry Pressing," *Jour. Amer. Ceram. Soc.*, **14** [12] 899–905 (1931).

[3] (*a*) *National Brick Mfrs. Assn. Bull.*, No. 109.
(*b*) C. M. Dodd, G. A. Page, and F. F. Netzeband, "Study of Dry-Press Process," *Brick Clay Rec.*, **78** [6] 322 (1931); *Ceram. Abs.*, **10** [6] 446 (1931).

[4] See C. M. Dodd and M. E. Holmes, footnote reference 2 (*j*).

(1) Dry-press mixes containing 50% grog gave the lowest apparent porosities when formed at 500 and 2000 pounds per square inch, except those clays which were naturally grogged and formed at the lower pressure. (2) The apparent porosities

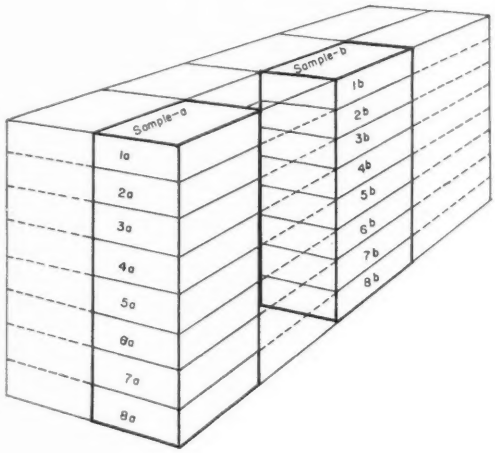


FIG. 1.

of the fine-grained clay mixes were lowered as the grog content was increased up to 50%, but they did not give as low porosities as the coarser-grained clay mixes of the same grog content. (3) The Cheltenham clay mixes, formed at 2000 pounds per square inch, increased in apparent porosity until a grog content of 20% was exceeded.

V. Grog Sizes[5]

(1) Procedure

The grog was ground in the dry pan and screened through the screens indicated in Table I and Fig. 2. Only one screen of the mesh designated was used in sizing the grog; the fines from each screen constituted the grog size of the mix. Because an attempt was made to simulate the easiest manufacturing procedure, further separation of the grog grain sizes was omitted.

A mixture of 30% grog and 70% clay was used in the blocks for this study. A moisture content of 8% (dry basis) was added. The blocks were formed at 500 pounds per square inch pressure.

[5] See H. R. Herron and S. J. Tompach, footnote reference 2(*c*).

(2) Discussion of Results

The mixes which contain surface clay give the highest apparent porosities even under optimum conditions. The lowest porosities are produced by north Missouri semiflint, with through −2.5-, through −4-, and through −8-mesh grog, all of which are approximately 22% apparent porosity. The Cheltenham mix, containing through −4-mesh grog, appears to be in error; numerous checks, however, were run on this mix, and the

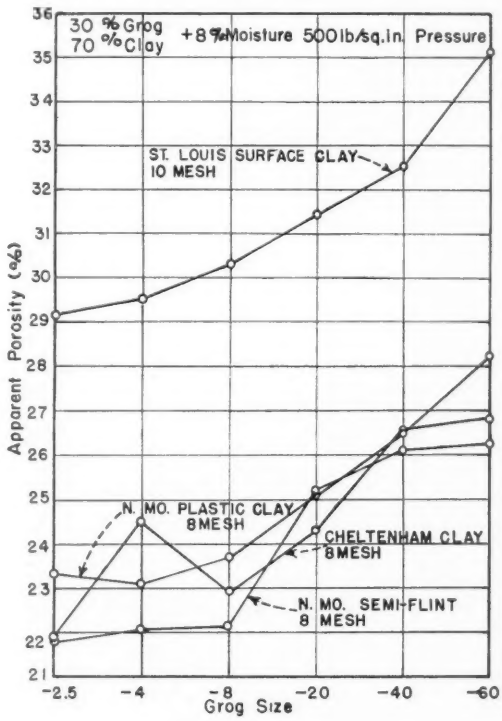


FIG. 2.

high value persisted. The north Missouri plastic clay mix is affected least by the size of grog grains. Except with the Cheltenham clay through −4-mesh grog mix, porosities may be lowered as much as 1.2% when grog sizes larger than through −8-mesh are used.

(3) Summary

(*a*) Increase in grog grain size gives lower apparent porosity in mixes of 30% grog, 70% clay, formed at 500 pounds per square inch.

(*b*) Increased grog size has least effect in lowering apparent porosity when the body contains a naturally grogged clay.

(*c*) As the maximum grain size of the grog is decreased below 8-mesh, the apparent porosity increase is more noticeable.

(*d*) Grog grain sizes of through −2.5-mesh and through −4-mesh give only slightly lower apparent porosities than those obtained with through −8-mesh grog.

NOTE: At this point, the fact that grain size has a marked effect on the rate and degree of vitrification should be emphasized. Therefore, the high porosity obtained with small grog grains in unfired ware may not persist in the fired ware.

VI. Clay Grain Size and Grain-Size Proportions[6]

(1) Procedure

The clays used were dry-pan ground to pass 4-mesh. Each of the clays was screened into four grain-size fractions as follows: through 4- on 8-mesh, through 8- on 20-mesh, through 20- on 60-mesh, and through 60-mesh. All mixes were tempered with 8% moisture (dry basis).

Each grain-size fraction was made up separately into blocks, and a series of blocks was made, composed of the coarsest fraction proportioned with the finest fraction by 20% intervals, as shown in Fig. 3 and Table II.

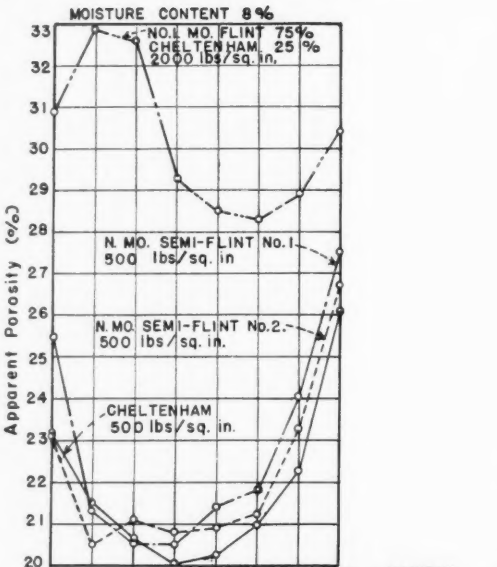


FIG. 3.

The blocks were formed at a pressure of 500 pounds per square inch applied for two seconds. Upon forming the mixture of No. 1 Missouri flint

[6] See C. M. Dodd, footnote reference 2 (*i*).

TABLE II

GRAIN SIZE AND GRAIN-SIZE PROPORTIONS

(Average Apparent Porosity and Normal Deviation from Average in Percentage)*

	(%)	(%)	(%)	(%)	(%)	(%)	(%)	(%)
−60-mesh grains			0	20	40	60	80	100
−29- + 60-mesh grains	100							
− 8- +20-mesh grains		100						
− 4- + 8-mesh grains			100	80	60	40	20	0
(1) No. 1 Mo. flint 75% and Cheltenham clay 25% (forming pressure 2000 lb./in.²)	30.99	32.93	32.60	29.29	28.54	28.36	28.94	30.40
	+1.51 (3)	+2.09	+1.38 (3)	+1.67 (2)	+2.29 (1)	+1.78 (1)	+1.68 (1)	+1.38 (3)
	−2.27 (8)	−2.32 (8)	−2.30 (8)	−2.20 (8)	−1.93 (8)	−1.75 (8)	−1.74 (8)	−2.11 (8)
	3.78 (*T*)	4.41 (*T*)	3.68 (*T*)	3.87 (*T*)	4.22 (*T*)	3.53 (*T*)	3.42 (*T*)	3.49 (*T*)
(2) No. 1 north Mo. semiflint (forming pressure 500 lb./in.²)	25.43	21.37	20.54	20.51	21.41	21.81	24.05	27.56
	+2.08 (4)	+1.35 (4)	+0.25 (3)	+0.79 (7)	+0.35 (7)	+0.82 (1)	+1.97 (4)	+1.96 (4)
	−1.62 (8)	−0.97 (8)	−0.19 (5)	−0.75 (4)	−0.38 (5)	−1.04 (8)	−1.57 (8)	−1.24 (8)
	3.70 (*T*)	2.32 (*T*)	0.44 (*T*)	1.54 (*T*)	0.73 (*T*)	1.86 (*T*)	3.54 (*T*)	3.20 (*T*)
(3) No. 2 north Mo. semiflint (forming pressure 500 lb./in.²)	23.13	20.50	21.11	20.81	20.95	21.24	23.32	26.76
	+1.19 (3)	+1.45 (4)	+0.79 (1)	+1.09 (1)	+1.05 (6)	+0.46 (4)	+1.18 (4)	+1.04 (5)
	−0.95 (8)	−1.03 (8)	−0.51 (8)	−0.71 (7)	−0.35 (8)	−0.44 (2)	−0.72 (7)	−0.86 (8)
	2.14 (*T*)	2.48 (*T*)	1.30 (*T*)	1.80 (*T*)	1.40 (*T*)	0.90 (*T*)	1.90 (*T*)	1.90 (*T*)
(4) Cheltenham clay (forming pressure 500 lb./in.²)	23.17	21.49	20.61	20.02	20.24	21.00	22.32	26.16
	+1.18 (4)	+1.19 (4)	+0.29 (5)	+0.73 (3)	+0.61 (2)	+1.00 (4)	+0.93 (4)	+1.49 (3)
	−1.12 (7)	−0.77 (8)	−0.21 (8)	−0.87 (5)	−0.54 (6)	−0.85 (7)	−0.27 (8)	−1.46 (8)
	2.30 (*T*)	1.96 (*T*)	0.50 (*T*)	1.60 (*T*)	1.15 (*T*)	1.85 (*T*)	1.20 (*T*)	2.95 (*T*)

Moisture content: 8% (dry basis).

* The number in parentheses following the normal deviation from the average apparent porosity indicates the layer in which the deviation occurs, and the percentage followed by *T*, the total deviation.

and Cheltenham clay at this pressure, the coarser-grained blocks were found to crumble too easily to allow handling; new batches were prepared and formed at 2000 pounds per square inch pressure to insure better bonding of the grains

(2) Discussion of Results

The Cheltenham clay and the two north Missouri semiflint clays show similar results. These decrease in porosity where the grain size of the clay particles is increased and no fine particles are included in the mix. The mixes, consisting of 20% grains through −60-mesh and 80% grains through −4- on 8-mesh, however, give the lowest porosities for these three clays, using these two grain-size fractions. As the fines in the composite mixes are increased up to 80% material through −60-mesh, the porosities increase, but these porosities are lower than those of the blocks made from 100% through −20- on −60-mesh and 100% through −60-mesh grains.

The No. 1 Missouri flint clay 75%-Cheltenham clay 25% mixes, formed at 2000 pounds per square inch, on the whole give higher porosities than the softer clays. Here, a maximum porosity is reached with through −8- on −20-mesh material, and a minimum porosity results when a mixture of 60% through −60-mesh and 40% through −4- on −8-mesh grain sizes are used. It is evident that this higher forming pressure and the lack of plasticity in the flint clay lower the porosity of the 100% through −60-mesh and the 100% through −20- on −60-mesh blocks more than would be expected when comparison is made with the more plastic clay blocks of the same grain sizes which were formed at 500 pounds per square inch. No logical explanation for this can be offered at present.

(3) Summary

(*a*) With plastic and semiplastic clays formed at 500 pounds per square inch, a mixture of 20% through −60-mesh and 80% through −4- on −8-mesh clay grains gives minimum apparent porosities for combinations of the largest and smallest grain sizes investigated.

(*b*) Decrease in grain size from through −4- on −8-mesh grains or an increase in amount of through−60-mesh grains above 20% in the composite grain-size mixes studied increases the apparent porosity of the unfired blocks formed at 500 pounds per square inch.

(*c*) High flintclay mixes, even when compressed at high pressure, give higher apparent porosities than plastic and semiplastic clay mixes compressed at lower pressures, regardless of grain size.

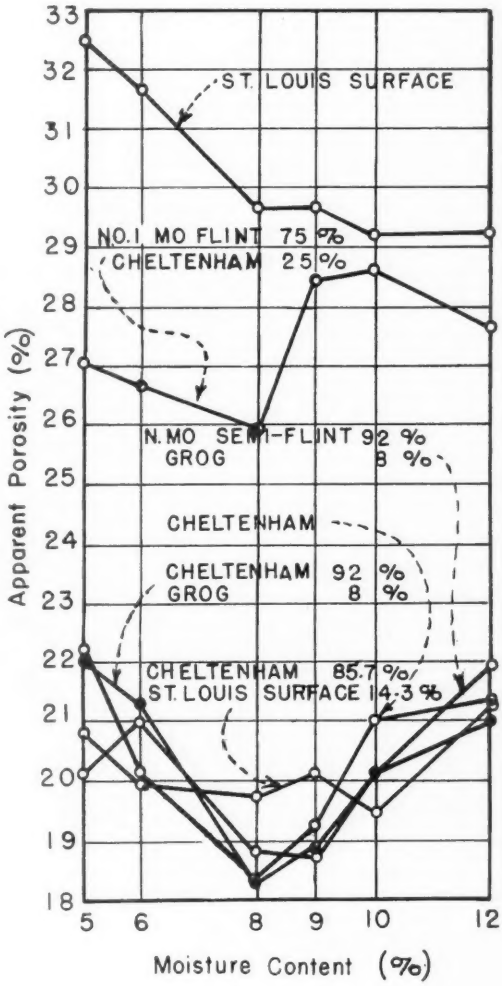


FIG. 4.

VII. Amount of Moisture[7]

(1) Procedure

The mixes containing grog and flint clay were dry-panned to pass 8-mesh, while the other three mixes were dry-panned to pass 10-mesh. All mixes were formed at 2000 pounds per square inch.

[7] See G. A. Page and F. F. Netzeband, footnote reference 2 (*d*).

The moisture content, as indicated in Fig. 4 and Table III, was on a dry basis.

(2) Discussion of Results

Both the St. Louis surface clay and the Cheltenham clay 85.7%-St. Louis surface clay 14.3% mixes give the lowest porosity with a 10% moisture content. The smaller grain sizes of the St. Louis surface clay require more moisture to lubricate the grains completely; moisture in excess of 10%, however, increases the porosity in both mixes. With the No. 1 Missouri flint clay 75%-Cheltenham clay 25% mix and the Cheltenham clay 92%-grog 8% mixes, only 8% moisture is required for minimum porosity. This low moisture requirement is in direct contrast with the surface-clay mixes, because in this mix a high percentage of the grains is large and presents less surface to be wetted.

The north Missouri semiflint clay 92%-grog 8% mix requires 9% moisture for the lowest porosity. Some indication of the effect of the amount of fine grains in a mix on the moisture content required to produce minimum porosity may be gained by examination of the through −200-mesh fraction of each of the above mixes, as follows:

Mixes	Percentage (through −200-mesh)
St. Louis surface clay	46.00
St. Louis clay 85.7% / Cheltenham clay 14.3%	24.53
No. 1 Mo. flint clay 75% / Cheltenham clay 25%	5.30
North Mo. semiflint clay 92% / Grog 8%	12.95
Cheltenham clay 92% / Grog 8%	9.89

TABLE III

MOISTURE CONTENT

(Average Apparent Porosity and Normal Deviation from the Average in Percentage)

Moisture content (%)	(5) (%)	(6) (%)	(8) (%)	(9) (%)	(10) (%)	(12) (%)	(14) (%)
(1) St. Louis surface clay (10-mesh)	32.53	31.73	29.67	29.63	29.20	29.27	
	+1.92 (3)	+1.64 (2)	+0.74 (3)	+1.34 (3)	+1.17 (4)	+0.65 (3)	
	−2.35 (1)	−1.40 (8)	−2.37 (4)	−1.44 (7)	−1.29 (8)	−0.69 (8)	
	4.27 (*T*)	3.04 (*T*)	3.11 (*T*)	2.78 (*T*)	2.46 (*T*)	1.34 (*T*)	
(2) No. 1 Mo. flint 75% and Cheltenham clay 25% (8-mesh)	27.06	26.68	25.94	28.44	28.63	27.67	27.10
	+1.24 (4)	+0.92 (6)	+0.41 (3)	+1.56 (4)	+0.88 (5)	+1.66 (1)	+1.08 (4)
	−2.10 (2)	−0.44 (7)	−0.23 (8)	−1.44 (7)	−0.76 (3)	−1.68 (8)	−1.38 (8)
	3.34 (*T*)	1.36 (*T*)	0.64 (*T*)	3.00 (*T*)	1.64 (*T*)	3.34 (*T*)	2.46 (*T*)
(3) North Mo. semiflint 92% and grog 8% (8-mesh)	20.17	21.02	18.82	18.77	20.14	21.95	
	+1.34 (5)	+1.34 (3)	+1.46 (4)	+0.71 (5)	+1.37 (5)	+0.83 (1)	
	−2.07 (1)	−0.74 (2)	−1.18 (3)	−0.43 (2)	−3.45 (7)	−0.52 (4)	
	3.41 (*T*)	2.08 (*T*)	2.64 (*T*)	1.14 (*T*)	4.82 (*T*)	1.35 (*T*)	
(4) Cheltenham (10-mesh)	22.20	20.19	18.42	19.28	21.00	21.35	
	+1.95 (3)	+1.35 (2)	+0.33 (1)	+1.85 (3)	+1.05 (5)	+0.85 (8)	
	−1.74 (8)	−2.20 (8)	−0.48 (4)	−1.67 (1)	−1.13 (2)	−0.85 (6)	
	3.69 (*T*)	3.55 (*T*)	0.81 (*T*)	3.52 (*T*)	2.18 (*T*)	1.70 (*T*)	
(5) Cheltenham 92% and grog 8% (8-mesh)	22.14	21.34	18.25	18.83	20.17	20.99	20.86
	+1.09 (3)	+1.79 (2)	+0.64 (7)	+0.77 (5)	+0.96 (5)	+1.09 (4)	+0.82 (6)
	−1.66 (8)	−1.98 (8)	−0.68 (3)	−0.76 (2)	−1.27 (8)	−1.22 (8)	−0.93 (5)
	2.75 (*T*)	3.77 (*T*)	1.32 (*T*)	1.53 (*T*)	2.23 (*T*)	2.31 (*T*)	1.75 (*T*)
(6) Cheltenham 85.7% and St. Louis surface clay 14.3% (10-mesh)	20.80	19.99	19.78	20.15	19.45	21.22	
	+1.59 (3)	+2.80 (3)	+1.37 (2)	+0.71 (7)	+1.35 (3)	+0.67 (4)	
	−2.47 (8)	−2.23 (8)	−0.58 (5)	−0.73 (5)	−0.86 (1)	−1.31 (5)	
	4.16 (*T*)	5.03 (*T*)	1.95 (*T*)	1.44 (*T*)	2.21 (*T*)	1.98 (*T*)	

Forming pressure: 2000 lb./in.[2].

* The number in parentheses following the normal deviation from the average apparent porosity indicates the layer in which the deviation occurs, and the percentage followed by *T*, the total deviation.

(3) Summary

(*a*) Mixes having a high percentage of fine-grained material require relatively high moisture content to produce minimum apparent porosity, when formed by dry-pressing at 2000 pounds per square inch pressure.

(*b*) The limits of moisture content to produce low apparent porosities in dry pressing fall between 8 and 10% (dry basis.)

VIII. Aging[8]

(1) Procedure

North Missouri plastic and semiflint clays were tempered with 10% moisture (wet basis) and stored in air-tight bins. Immediately after tempering, blocks were formed at 500 pounds per square inch applied for two seconds, also after 1, 2, 4, 8, and 14 days and from then on at intervals of two weeks, as shown in Fig. 5.

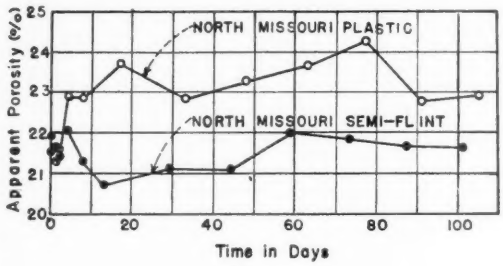


FIG. 5.

porosity, and aging beyond this increases the porosity. With the north Missouri semiflint clay, the apparent porosity is changed less than 1% by aging from 13 to 44 days, after which period the porosity is little different from the porosity obtained when the clay is not aged.

(3) Summary

(*a*) Aging of the tempered clays studied, for periods up to 100 days, has very little, if any, beneficial effect upon lowering the apparent porosity of the formed blocks.

IX. Duration of Maximum Pressure[9]

(1) Procedure

The moisture content of the various mixes was adjusted to 7% (dry basis). The blocks were formed by the regular pressing method, but when the forming pressure of 2000 pounds per square inch was attained, it was held for the number of seconds indicated by the abscissas in Fig. 6.

[9] See R. E. Lee, footnote reference 2 (*f*).

TABLE IV

AGING

(Average Apparent Porosity and Normal Deviation from the Average Number in Percentage)*

Time of aging (days)	North Missouri plastic clay (8-mesh)			North Missouri semiflint clay (8-mesh)		
	(av.) (%)	(deviation) (%)	(%)	(av.) (%)	(deviation) (%)	(%)
0	21.94	+0.36 (1)–0.45 (8)	0.81 (*T*)	21.56	+0.52 (5)–0.27 (7)	0.79 (*T*)
1	21.37	+0.44 (5)– .60 (6)	1.04 (*T*)	21.68	+ .78 (2)– .10 (8)	0.88 (*T*)
2	21.61	+0.44 (3)– .28 (7)	0.72 (*T*)	21.47	+ .31 (1)– .22 (8)	0.53 (*T*)
4	22.95	+0.79 (7)– .65 (4)	1.44 (*T*)	22.09	+ .18 (2)– .24 (8)	0.42 (*T*)
8	22.84	+0.29 (1)– .29 (5)	0.58 (*T*)	21.29	+ .36 (2)– .78 (8)	1.14 (*T*)
13				20.78	+ .59 (2)– .41 (7)	1.00 (*T*)
17	23.72	+0.91 (4)– .89 (8)	1.80 (*T*)			
29				21.14	+ .63 (2)– .32 (8)	0.95 (*T*)
33	22.84	+0.33 (2)– .51 (5)	0.84 (*T*)			
44				21.10	+ .29 (1)– .31 (3)	0.60 (*T*)
48	23.28	+0.47 (5)– .65 (7)	1.12 (*T*)			
59				22.00	+ .87 (2)– .79 (8)	1.66 (*T*)
63	23.69	+0.39 (2)– .72 (5)	1.11 (*T*)			
73				21.82	+ .48 (3)– .84 (8)	1.32 (*T*)
77	24.23	+1.51 (3)– .69 (8)	2.20 (*T*)			
87				21.64	+ .41 (4)– .58 (6)	0.99 (*T*)
91	22.79	+0.51 (2)– .79 (8)	1.30 (*T*)			
101				21.62	+ .42 (6)– .39 (4)	0.81 (*T*)
105	22.94	+0.38 (3)– .66 (4)	1.04 (*T*)			

Forming pressure: 500 lb. /in.^{2}.

* The number in parentheses following the normal deviation from the average apparent porosity indicates the layer in which the deviation occurs.

(2) Discussion of Results

According to Kay,[8] the blocks for which the plastic clay was aged eight days and the semiflint was aged for four days show the most uniform porosity throughout. The north Missouri plastic clay, when aged for one day, gives the lowest

[8] See W. T. Kay, footnote reference 2 (*e*).

(2) Discussion of Results

With an increase in the length of time of pressure duration, those mixes which contain 8% of firebrick grog are the only mixes in this study which show a consistent marked deviation from the apparent porosity value obtained at 2 seconds' pressing at 2000 pounds per square inch. At 8

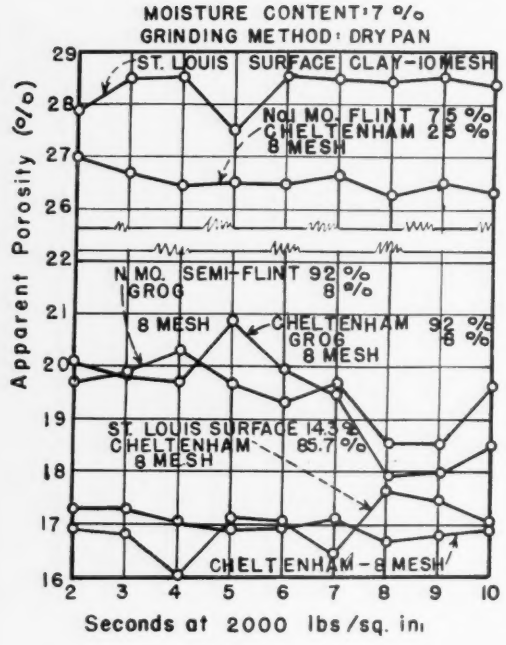


FIG. 6.

and 9 seconds' pressure duration, the minimum porosity for these grogged mixes is attained.

After four seconds' pressure application, the porosity of the No. 1 Missouri flint clay 75%-Cheltenham clay 25% mix shows a substantially constant porosity, which is lower than that obtained at shorter periods. The Cheltenham clay mix performs in a manner similar to the flint Cheltenham mix but to a lesser degree.

(3) Summary

(*a*) Length of dwell of ram at maximum pressure shows little or no effect on lowering the apparent porosity of a dry-press mix formed at 2000 pounds per square inch, except where firebrick grog comprises part of the mix.

(*b*) Minimum apparent porosities under these conditions were found to exist at 8 and 9 seconds' pressure duration when the mix contained 8% firebrick grog.

X. Forming Pressure[7]

(1) Procedure

The moisture content of the mixes was adjusted to 7% (dry basis). Through −10-mesh material

TABLE V

DURATION OF MAXIMUM PRESSURE

(Average Apparent Porosity and Normal Deviation from the Average Number in Percentage)*

	Duration of maximum pressure								
	2 sec. (%)	3 sec. (%)	4 sec. (%)	5 sec. (%)	6 sec. (%)	7 sec. (%)	8 sec. (%)	9 sec. (%)	10 sec. (%)
(1) St. Louis surface clay (10 mesh)	27.88	28.50	28.51	27.56	28.59	28.48	28.42	28.52	28.39
	+0.58 (4)	+0.59 (3)	+0.71 (4)	+0.54 (4)	+0.81 (4)	+0.94 (4)	+1.08 (4)	+0.93 (4)	+0.78 (4)
	−0.74 (8)	−1.40 (8)	−1.01 (8)	−1.06 (8)	−0.69 (8)	−1.71 (8)	−1.32 (8)	−1.07 (8)	−1.24 (8)
	1.32 (*T*)	1.99 (*T*)	1.72 (*T*)	1.60 (*T*)	1.50 (*T*)	2.65 (*T*)	2.40 (*T*)	2.00 (*T*)	2.02 (*T*)
(2) No. 1 Mo. flint 75% and Cheltenham 25% (8-mesh)	27.00	26.76	26.44	26.45	26.51	26.68	26.28	26.50	26.37
	+0.82 (2)	+0.84 (2)	+0.76 (4)	+1.05 (3)	+0.79 (3)	+0.72 (5)	+0.62 (3)	+0.80 (4)	+0.78 (4)
	−1.18 (8)	−1.46 (8)	−1.24 (8)	−1.00 (8)	−0.68 (8)	−0.98 (8)	−1.08 (8)	−0.90 (8)	−1.02 (8)
	2.00 (*T*)	2.30 (*T*)	2.00 (*T*)	2.05 (*T*)	1.47 (*T*)	1.70 (*T*)	1.70 (*T*)	1.70 (*T*)	1.80 (*T*)
(3) Cheltenham 92% and grog 8% (8-mesh)	20.11	19.82	19.76	20.83	19.98	19.46	17.94	17.97	18.46
	+0.59 (3)	+1.02 (1)	+1.24 (1)	+1.65 (1)	+0.23 (5)	+0.35 (3)	+0.18 (2)	+0.63 (2)	+0.95 (3)
	−0.76 (8)	−0.82 (8)	−1.20 (8)	−1.55 (8)	−0.45 (8)	−0.26 (8)	−0.62 (8)	−0.45 (8)	−0.45 (8)
	1.35 (*T*)	1.84 (*T*)	2.44 (*T*)	3.20 (*T*)	0.68 (*T*)	0.61 (*T*)	0.80 (*T*)	1.08 (*T*)	1.40 (*T*)
(4) North Mo. semiflint 92% and grog 8% (8-mesh)	19.76	19.88	20.37	19.64	19.35	19.65	18.58	18.53	19.67
	+0.59 (2)	+0.83 (2)	+1.06	+0.66 (3)	+0.85 (1)	+0.70 (3)	+1.25 (1)	+0.94 (1)	+1.18 (1)
	−1.44 (8)	−1.45 (8)	−1.56 (8)	−1.22 (7)	−0.81 (8)	−1.15 (8)	−1.58 (8)	−0.78 (8)	−1.33 (8)
	2.03 (*T*)	2.28 (*T*)	2.62 (*T*)	1.88 (*T*)	1.66 (*T*)	1.85 (*T*)	2.83 (*T*)	1.72 (*T*)	2.51 (*T*)
(5) Cheltenham 85.7% and St. Louis surface clay 14.3% (10-mesh)	16.98	16.81	16.02	17.18	17.04	16.48	17.68	17.43	17.06
	+1.27 (1)	+0.79 (1)	+1.63 (1)	+1.12 (1)	+0.84 (1)	+1.55 (1)	+0.62 (4)	+0.74 (1)	+1.01 (1)
	−1.13 (8)	−0.86 (8)	−0.56 (8)	−0.46 (8)	−0.42 (8)	−1.16 (5)	−0.82 (8)	0.54 (8)	−0.57 (8)
	2.40 (*T*)	1.65 (*T*)	2.19 (*T*)	1.58 (*T*)	1.26 (*T*)	2.71 (*T*)	1.44 (*T*)	1.28 (*T*)	1.58 (*T*)
(6) Cheltenham (10-mesh)	17.34	17.34	17.01	16.94	16.96	17.19	16.65	16.82	16.99
	+1.24 (1)	+1.51 (3)	+1.39 (2)	+1.24 (1)	+1.42 (1)	+0.78 (2)	+0.79 (3)	+1.25 (2)	+0.83 (2)
	−1.09 (8)	−1.34 (8)	−0.86 (8)	−0.94 (8)	−1.71 (8)	−1.04 (8)	−0.55 (8)	−1.22 (7)	−1.04 (8)
	2.33 (*T*)	2.85 (*T*)	2.25 (*T*)	2.28 (*T*)	3.13 (*T*)	1.82 (*T*)	1.34 (*T*)	2.47 (*T*)	1.87 (*T*)

Forming pressure: 2000 lb./in.².
Moisture content: 7% (dry basis).
Grinding method: dry pan.

* The number in parentheses following the normal deviation from the average apparent porosity indicates the layer in which the deviation occurs, and the percentage followed by *T*, the total deviation.

comprised the St. Louis surface clay mixes, and through −8-mesh material was used in the others. Forming was done at the pressures indicated as abscissas in Fig. 7. The forming pressure was held for two seconds before being released.

(2) Discussion of Results

Obviously, the higher forming pressures produce lower apparent porosities. The No. 1 Missouri flint clay 75%-Cheltenham clay 25% mix benefits the least in lowered porosities, and the Cheltenham clay 85.7%-St. Louis surface clay 14.3% mix benefits the most by being formed at the higher pressures. The north Missouri semiflint 92%-grog 8% mix also benefits by increased pressure, as indicated by the large difference in apparent porosity between the lower and higher pressures.

Disregarding the results obtained on the 100% St. Louis surface clay blocks, increased pressures produce greater decrease in apparent porosity as the amount of through −200-mesh material in the mix increases.[10]

(3) Summary

(*a*) The apparent porosity of dry-pressed brick mixes is decreased as the forming pressure is increased.

(*b*) In general, increase in forming pressure has a greater effect on lowering the apparent porosity as the percentage of through −200-mesh material in the mix is increased.

XI. Vacuum Treatment[11]

(1) Procedure

(*a*) The various mixes indicated in Table VII were dry-pan ground. The mixes which contained surface clay were screened to pass 10-mesh and the others 8-mesh. The moisture content was adjusted to 7% (dry basis). The blocks were formed in the regular manner at 2000 pounds per square inch applied for two seconds, as well as with a vacuum of about 26 inches of mercury at the beginning and 18 inches at the end of compression.

(*b*) Pressures as shown in Table VIII were employed on the north Missouri semiflint clay (No. 2) 92%-grog 8% mix, which was formed under vacuum and also in the regular way.

(2) Discussion of Results

(*a*) Less than 1% variation in apparent porosity results from the vacuum and the regular treatment of the same mix, except the one selected for (*b*), where the vacuum treatment gives about 1.4% higher porosity than the regular treatment.

TABLE VI

FORMING PRESSURE

(Average Apparent Porosity and Normal Deviation from the Average in Percentage)*

Forming pressure (lb./in.²)	500 lb. (%)	1000 lb. (%)	1500 lb. (%)	2000 lb. (%)	3000 lb. (%)	4000 lb. (%)
(1) St. Louis surface clay (10-mesh)	36.19 +1.70 (4) −3.02 (8) 4.72 (*T*)	34.21 +1.45 (4) −1.40 (8) 2.85 (*T*)	33.48 +1.09 (3) −1.95 (8) 3.04 (*T*)	32.17 +1.88 (1) −1.56 (8) 3.44 (*T*)	30.72 +2.20 (1) −3.04 (8) 5.24 (*T*)	29.42 +2.29 (1) −2.97 (8) 5.26 (*T*)
(2) No. 1 Mo. flint 75% and Cheltenham clay 25% (8-mesh)	30.60 +1.01 (3) −2.68 (8) 3.69 (*T*)	28.79 +1.23 (3) −1.54 (*T*) 2.77 (*T*)	28.68 +0.95 (3) −1.77 (8) 2.72 (*T*)	27.83 +1.28 (2) −1.52 (8) 2.80 (*T*)	27.57 +1.31 (2) −1.35 (8) 2.66 (*T*)	26.95 +1.15 (1) −1.27 (8) 2.42 (*T*)
(3) North Mo. semiflint 92% and grog 8% (8-mesh)	25.73 +0.70 (3) −0.98 (8) 1.68 (*T*)	24.01 +1.37 (3) −1.44 (8) 2.81 (*T*)	22.34 +1.24 (2) −1.99 (8) 3.23 (*T*)	21.68 +1.56 (2) −1.73 (8) 3.29 (*T*)	19.98 +1.61 (2) −1.27 (8) 2.88 (*T*)	19.12 +1.13 (1) −1.48 (8) 2.61 (*T*)
(4) Cheltenham clay 85.7% and St. Louis surface clay 14.3% (10-mesh)	26.97 +2.43 (3) −3.43 (8) 5.86 (*T*)	26.03 +2.69 (2) −4.20 (8) 6.89 (*T*)	23.05 +3.08 (1) −3.94 (8) 7.02 (*T*)	20.37 +3.44 (1) −3.47 (8) 6.91 (*T*)	19.40 +3.81 (1) −3.40 (8) 7.21 (*T*)	17.32 +3.34 (1) −2.25 (8) 5.59 (*T*)
(5) Cheltenham clay 92% and grog 8% (8-mesh)	22.49 +0.54 (3) −0.57 (8) 1.11 (*T*)	20.50 +0.75 (6) −0.96 (8) 1.71 (*T*)	19.80 +0.54 (3) −0.57 (8) 1.11 (*T*)	19.35 +0.37 (4) −0.55 (8) 0.92 (*T*)	18.04 +0.59 (2) −0.72 (8) 1.31 (*T*)	18.12 +0.74 (2) −0.55 (7) 1.29 (*T*)

Moisture content: 7% (dry basis).

* The number in parentheses following the normal deviation from the average apparent porosity indicates the layer in which the deviation occurs, and the percentage followed by *T*, the total deviation.

[10] These 200-mesh values are the same as those given under Section VII (2), p. 470.

[11] See W. R. Powell, footnote reference 2 (*g*).

Powell[11] found that in all cases the regular treatment gives better pressure transmission throughout the block than that resulting from the vacuum treatment. The results here obtained, *i.e.*, small variation in density between the two forming methods, conform closely to the results obtained by Rueckel.[12]

TABLE VII

VACUUM TREATMENT OF VARIOUS TYPES OF MIXES

(Average Apparent Porosity and Normal Deviation from the Average in Percentage)*

Forming method	Regular (%)	Vacuum (%)
St. Louis surface clay (10-mesh)	30.19	30.47
	+0.47 (5)	+1.69 (1)
	−0.67 (1)	−0.87 (8)
	1.14 (*T*)	2.56 (*T*)
No. 1 Missouri flint 75% and Cheltenham 25% (8-mesh)	25.87	26.09
	+0.48 (4)	+0.83 (2)
	−0.27 (1)	−0. 88(8)
	0.75 (*T*)	1.71 (*T*)
North Mo. semiflint No. 2 92% and grog 8% (8-mesh)	20.19	21.58
	+0.41 (3)	+2.58 (1)
	−0.39 (8)	−2.04 (8)
	0.80 (*T*)	4.62 (*T*)
North Mo. semiflint No. 1 92% and grog 8% (8-mesh)	19.34	19.31
	+0.89 (4)	+1.79 (1)
	−0.49 (7)	−2.15 (8)
	1.38 (*T*)	3.94 (*T*)
St. Louis surface clay 14.3% and Cheltenham 85.7% (10-mesh)	17.29	18.15
	+0.49 (4)	+2.26 (1)
	−0.40 (1)	−2.52 (8)
	0.89 (*T*)	4.78 (*T*)

Forming pressure: 2000 lb./in.².
Moisture content: 7%.

* The number in parentheses following the normal deviation from the average apparent porosity indicates the layer in which the deviation occurs, and the percentage followed by *T*, the total deviation.

TABLE VIII

VACUUM TREATMENT AT VARIOUS PRESSURES

(Average Apparent Porosity and Normal Deviation from the Average in Percentage)*

Forming pressure	500 lb./in.² (%)	2000 lb./in.² (%)	3000 lb./in.² (%)	4000 lb./in.² (%)
Regular method	23.00	20.19	18.45	18.37
	+0.48 (4)	+0.41 (3)	+0.65 (2)	+0.99 (2)
	−0.82 (8)	−0.39 (8)	−0.62 (8)	−1.05 (8)
	1.30 (*T*)	0.80 (*T*)	1.27 (*T*)	2.04 (*T*)
Vacuum method	24.19	21.58	18.42	18.41
	+1.61 (1)	+2.54 (1)	+1.78 (1)	+1.48 (1)
	−1.61 (8)	−2.04 (8)	−0.82 (8)	−1.19 (7)
	3.22 (*T*)	4.58 (*T*)	2.60 (*T*)	2.67 (*T*)

Mix: North Missouri semiflint (No. 2) 92% and grog 8%.
Moisture content: 7%.

* The number in parentheses following the normal deviation from the average apparent porosity indicates the layer in which the deviation occurs, and the percentage followed by *T*, the total deviation.

[12] W. C. Rueckel, "Researches in Dry-Press Refractories: III, Effect of Vacuum on Unfired Properties of Some Dry-Press Refractory Batches," *Jour. Amer. Ceram. Soc.*, **14** [10] 764–69 (1931); p. 768.

NOTE: The results of vacuum treatment formerly published[13] were a combination of the work of Powell[11] and Page[7]; a careful check of the data, however, leads the writer to believe that enough of the human element enters into the operation of the press to cause considerable variation in the results obtained by two different operators.

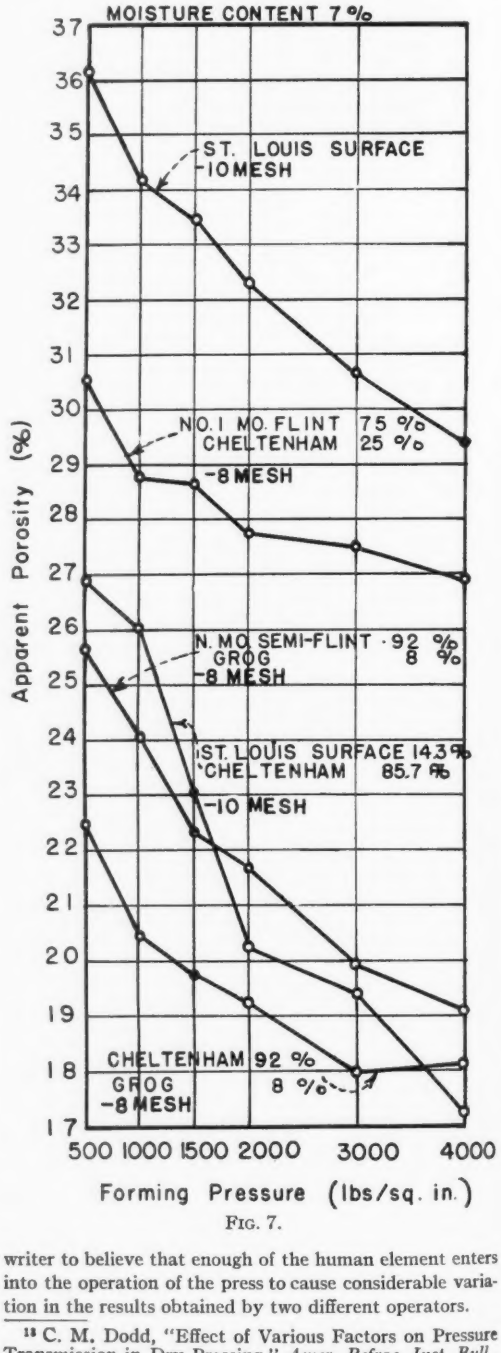


FIG. 7.

[13] C. M. Dodd, "Effect of Various Factors on Pressure Transmission in Dry Pressing," *Amer. Refrac. Inst. Bull.*, No. 33 (March, 1932).

(*b*) At 500 and 2000 pounds per square inch forming pressures, the north Missouri semiflint clay (No. 2) 92%-grog 8% mix shows substantially the same difference in apparent porosity between the regular and the vacuum methods of forming. At the higher forming pressures of 3000 and 4000 pounds per square inch, the difference is negligible.

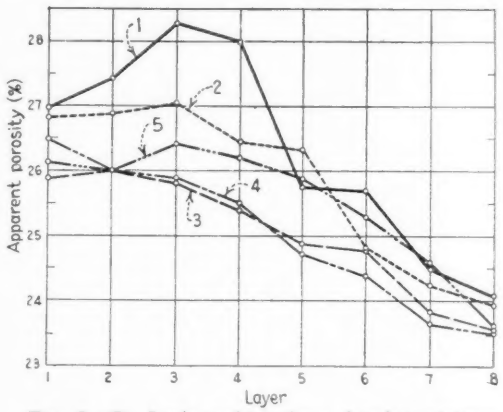


FIG. 8.—St. Louis surface clay: forming pressure 2000 lb./sq. in.; moisture 10%. Curve No. 1, no current; curve No. 2, one electrode (5 amp.); curve No. 3, two electrodes (6.5 amp.); curve No. 4, two electrodes and electrolyte (7 amp., NH_4Cl); curve No. 5, no current, electrolyte (NH_4Cl).

(3) Summary

(*a*) Vacuum treatment of dry-press mixes gives poorer pressure transmission in the mix and slightly higher apparent porosities.

(*b*) Forming pressures above 3000 pounds per square inch eliminate the difference in apparent porosity produced by vacuum treatment and regular forming at lower pressures of semiflint clay-grog mixes.

NOTE: While vacuum treatment does not give greater density than the regular treatment, it does allow the use of higher forming pressure without the appearance of pressure cracks.[14]

XII. Electrical Die Lubrication[15]

(1) Justification

Previous work on obtaining a uniform structure in dry-press formed brick mixes indicated that the arching of the mix due to drag on the mold liners is responsible to a large degree for insufficiently compressed centers. Pilot tests show that lubricants of high viscosity, such as vaseline, tend to reduce the high apparent porosity which is present in the center of brick formed under similar conditions without lubrication. The application of a grease to mold boxes for lubrication is impractical because of the mechanical difficulties involved. Chromium plating of the mold-box liners to give a hard, slick surface has been suggested[13] as an aid to lubrication.

The fundamental principle of electrolubrication is not new. Dawkins[16] states that if metal in contact with clay is made cathode, and a current is passed, the clay no longer tends to adhere, and all of the effects of lubrication are obtained. Everhart has applied this method successfully to lubricate soft-mud[17] molds and stiff-mud[18] dies.

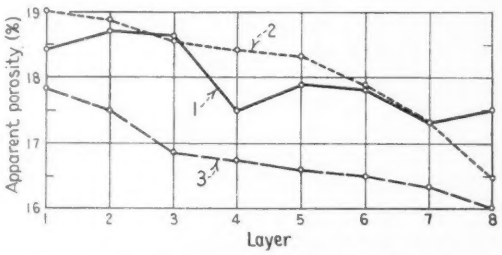


FIG. 9.—North Missouri semiflint 85.7%-St. Louis surface clay 14.3%: forming pressure 2000 lb./sq. in.; moisture 9.4%. Curve No. 1, no current; curve No. 2, one electrode (5 amp.); curve No. 3, two electrodes (6.5 amp.).

Clay in the semiliquid or plastic states should be subject to "cataphoresis"[19] (migration of the particles in suspension to the positive electrode when subjected to an electrical potential) and "endosmosis"[19] (travel of a liquid through a porous medium to the negative electrode when subject to an electrical potential). In a dry-press mix with a moisture content not in excess of 10% of the dry weight, endosmosis is more probable than cataphoresis. Therefore, endosmosis should be effective as a lubricant to give uniform pressure transmission.

[14] R. E. Birch, private communication.

[15] See O. W. Kamper, footnote reference 2 (*h*).

[16] J. R. Dawkins, "Electricity as Applied to Clay," *Brit. Clayworker*, **22**, 91–92 (1913); *Clayworker*, **57**, 246 (1912).

[17] J. O. Everhart, "Electrical Lubrication of Hand-Molded Refractory Shapes," *Jour. Amer. Ceram. Soc.*, **17** [10] 312–13 (1934).

[18] J. O. Everhart, "Electrical Lubrication of Stiff-Mud Dies," *ibid.*, **17** [9] 272–79 (1934).

[19] D. R. Briggs, "Electrical Endosmosis and Cataphoresis," *Second Rept. on Colloid Chemistry*, pp. 26–47 (1918). British Assn. for the Advancement of Science, London.

(2) Procedure

A modification of the method formerly used for the determination of the uniformity of pressure transmission in dry-press brick mixes[20] was used.

(*a*) *Sizing and Tempering:* All clays were ground through rolls, and the tailings were reground until the entire batch passed the screen indicated.

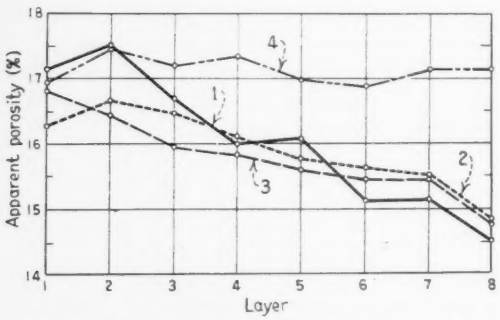


FIG. 10.—Missouri semiflint 92%-firebrick grog 8%: forming pressure 2000 lb./sq. in.; moisture 8 and 9%. Curve No. 1, no current; curve No. 2, one electrode (14 amp.); curve No. 3, two electrodes (6 amp.); curve No. 4, two electrodes and electrolyte (7 amp., NH_4Cl).

The tempering was done in a large tub by hand mixing and repassing the mix through a coarse screen to break up any lumps. The tempering water was added on a dry basis after a moisture determination had been made on each mix. To insure uniform moisture distribution, each mix was aged in closed containers for twenty-four hours.

(*b*) *Forming:* The mix was introduced into the mold box in two-inch layers, all of which were approximately the same weight. Each layer was separated by a piece of waxed paper with a tin foil insert to conduct current through the separator. Eight layers were charged into the mold box for each mix. A pressure of 2000 pounds per square inch was applied and maintained for three seconds.

During the pressing, direct current was applied. The current was turned on as soon as the ram movement started and was continued until the block was released from the mold box

At first, only one positive electrode was placed on top of the mix in the mold box, but later, another positive electrode was placed at the bottom. Positive current was applied through these electrodes, while the mold box acted as the negative pole. At the start of pressure application, little current flowed, but as the compression increased and better contact was established, the current flow increased. A rheostat was connected in the line to prevent excessive current flow. The upper limit was fifteen amperes, and the lower limit five amperes.

When used, the electrolyte consisted of a $^1/_{10}$ *N* solution of ammonium chloride, which was added as tempering water to increase the conduction of the current through the moist mix.

(*c*) *Sampling and Drying:* After forming, the blocks were removed from the mold box, the layers were separated, and samples were obtained (Fig. 1). Samples were held at room temperature for twenty-four hours, and then were dried for an additional twenty-four hours at 110°C.

Apparent porosities were obtained on each sample by saturation with kerosene under a vacuum of twenty inches of mercury for three hours. The average apparent porosity of the two samples from each layer was calculated and plotted against the layer number to obtain the curves shown in the plots.

(3) Discussion of Results

(*a*) *St. Louis Surface Clay:* This particular clay was selected because former investigations[21] showed it to give greater variation in apparent porosity from top to bottom of the block when no attempt is made to lubricate the mold box. Therefore,

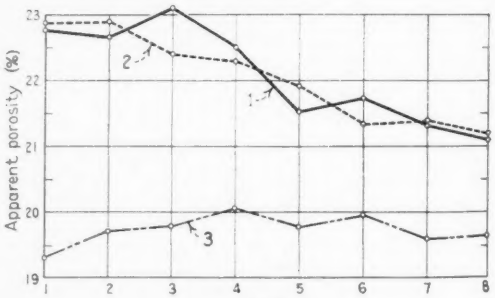


FIG. 11.—North Missouri semiflint 25%-Missouri No. 1 flint 75%: forming pressure 2000 lb./sq. in.; moisture 8 and 10%. Curve No. 1, no current; curve No. 2, one electrode (7.5 amp.); curve No. 3, two electrodes and electrolyte (7 amp., NH_4Cl).

it will act as a good criterion in determining the effect of electrical lubrication on pressure transmission. In the curve where no current is applied, an increase in porosity in the center layers

[20] See C. M. Dodd, G. A. Page, and F. F. Netzeband, footnote reference 3 (*b*).

[21] See C. M. Dodd, footnote reference 13.

is quite noticeable, and the porosity drops off rapidly in the lower layers which are more compressed, owing to the application of pressure by the lower ram only (see Fig. 8). When one electrode is used at the top of the block, a much more uniform distribution of pressure is indicated by the gradual slope of the curve for layers (1) to (5). The use of two electrodes shows the best pressure transmission throughout the block, as indicated by the more gradual and more nearly uniform gradient in apparent porosity from top to bottom of the block. The addition of electrolyte and use of two electrodes give no advantage over the use of two electrodes alone for the St. Louis surface clay. When electrolyte (and no current) is used, the result is intermediate between that obtained with one electrode and two electrodes.

(*b*) *North Missouri Semiflint 85.7%-St. Louis Surface Clay 14.3%:* With this mix (Fig. 9), the curve for no current application shows a pressure transmission that is not uniform. The use of one electrode, however, gives very little, if any, advantage over the results obtained with no current. Two electrodes tend to decrease the porosity throughout the block and give a more gradual gradient to the porosity curve from top to bottom of the block, which indicates more uniform pressure transmission throughout.

(*c*) *North Missouri Semiflint 92%-Firebrick Grog 8%:* With this mix, a gradual increase in uniformity of transmission of pressure is experienced by the use of one and two electrodes over that which is obtained where no current is applied (Fig. 10). The addition of electrolyte with the use of current top and bottom gives an increased porosity to the bottom layers of the block and indicates a uniform transmission of pressure throughout the structure.

(*d*) *North Missouri Semiflint 25%-Missouri No. 1 Flint 75%:* The use of one electrode gives little or no advantage over the use of no current with this mix (Fig. 11). When electrolyte and current are used, the porosity of the entire block is materially decreased, and a uniform pressure transmission results as is indicated by the almost horizontal curve obtained.

(4) Summary

(*a*) A definite increase in uniformity of pressure transmission is produced by the use of a positive electrode on the top and bottom ram and a negative electrode on the mold box when compressing a dry-press mix which contains an electrolyte over that obtained when no current and no electrolyte are used.

(*b*) Two electrodes and electrolyte give lowest apparent porosities in all mixes studied, except the semiflint clay-grog mix, where they produce the highest porosity of any method used.

XIII. General Conclusions

(1) Dry-press mixes through 8-mesh which contain 50% grog, formed at 500 and 2000 pounds per square inch, produce unfired blocks of lower apparent porosity than mixes containing higher or lower percentages of grog.

(2) Increase in the size of grog grains decreases the apparent porosity of unfired dry-pressed blocks formed from 30% grog-70% clay mixes at 500 pounds per square inch.

(3) Increase in clay-grain size decreases the apparent porosity of unfired dry-press ware formed at 500 pounds per square inch.

(4) Between 6 and 10% (dry basis) moisture content will produce the lowest apparent porosities in dry-pressed refractory mixes.

(5) Aging of tempered dry-press mixes up to 100 days produces little variation in the apparent porosity of the formed blocks.

(6) The length of time in excess of two seconds that the forming pressure is maintained has no effect on lowering apparent porosities of unfired dry-pressed blocks.

(7) The apparent porosities of dry-pressed brick mixes decrease as the forming pressure is increased.

(8) Application of vacuum to dry-press mixes during forming produces slightly higher apparent porosities and less uniformity of pressure transmission than when regular methods are used.

(9) When dry-press mixes are tempered with 8% of a 0.1 *N* solution of NH_4Cl and a direct current of 7 amperes passes uniformly from the mix to the mold box, electrical lubrication of dry-press dies is effective in producing uniformity in the pressure transmitted to the entire mix. This treatment, however, does not always produce maximum bulk density in the formed mix.

Acknowledgment

The experiments from which most of the data for this paper are taken were made possible by the financial and advisory help of the former N.B.M.A. Committee on Dry-Press Process and its successor, the Missouri Committee on Dry-Press Process.

Department of Ceramic Engineering
Missouri School of Mines and Metallurgy
Rolla, Missouri

ACTIVITIES OF THE SOCIETY

MEETINGS PLANNED

Forty-First Annual Meeting, Hotel Stevens, Chicago, Ill., April 16–22, 1939

General Meeting, Hotel St. Francis, San Francisco, Calif., week of August 6, 1939

Art Division and Pittsburgh Section, University of Pittsburgh and Mellon Institute, January 10, 1939

FORTY-FIRST ANNUAL MEETING, AMERICAN CERAMIC SOCIETY

Stevens Hotel, April 16 to 22, 1939

Committee Appointments

The following committees have been announced to serve the members of the Society at the Forty-First Annual Meeting to be held at the Stevens Hotel, Chicago, Ill., April 16 to 22, 1939.

Executive

Frank E. Hodek, Jr., *Chairman*
E. C. Aydelott, *Vice-Chairman*
A. L. Vodicka, *Vice-Chairman*
Rex Newcomb, Jr., *Secretary*
A. I. Andrews
Wm. Hoganson
Rudyard Porter
Fred L. Steinhoff

General

George Arras
J. A. Dedouch
Hugo Filippi
Walter Gavin
F. A. Guignon
George Hanson
G. G. Kent
W. C. Lindemann
M. E. Manson
R. S. Olson
Robert Onan
Howard Parman
C. W. Parmelee
Frank Porter
Burnett Purcell
B. S. Radcliffe
Thomas Rogers
Kenneth Strong
Bert Sweely
J. C. Vollrath

Publicity

Edward Goetz, *Chairman*
H. Dana Chase
Rex Newcomb, Jr.

Entertainment

R. A. Beverley, *Chairman*
Fred Buck
Bart Fennessy
C. L. Frederick, Jr.
E. W. Woodruff
Richard Goble
H. J. Shaner
Bruce Wagner
D. B. Walters

Plant Visitation

March Nagle, *Chairman*
E. R. Brauner
J. A. DeCelle
L. I. Shaw
E. H. Haeger
Carl E. Lyon
Howard Parman

Transportation

George G. Hanson, *Chairman*
Roger Fellows
John T. Roberts

Women's

Mrs. Myrtle French, *Chairman*
Mrs. A. I. Andrews
Mrs. Edward Goetz
Mrs. R. S. Olson
Mrs. Rudyard Porter
Mrs. J. T. Roberts

Proposed Plant Visits

Art Division

Art Institute, Chicago
Haeger Pottery, Dundee, Ill.
Pickard, Inc., Chicago, Ill.

Enamel Division

Chicago Hardware & Foundry Co., North Chicago
Chicago Vitreous Enamel Product Co., Cicero
Benjamin Electric Co., Des Plaines, Ill.
General Porcelain Enameling & Mfg. Co., Chicago
Chicago Porcelain Co., Chicago
Inland Steel Co., Indiana Harbor, Ind.

Terra Cotta and Structural Clay Products Divisions

Northwestern Terra Cotta Co., Chicago
Illinois Brick Co. (Plant 17), Chicago
Streator Brick Co., Streator, Ill.
Midwest Brick Co., Ottawa, Ill.

Glass Division

Owens-Illinois Glass Co., Streator, Ill.
Thatcher Mfg. Co., Streator, Ill.
Owens-Illinois Glass Co., Chicago Heights, Ill.
Libbey-Owens-Ford Glass Co., Ottawa, Ill.
Inland Glass Co., Chicago, Ill.

White Wares Division

Haeger Pottery Co., Dundee, Ill.
Pickard, Inc., Antioch, Ill.

Refractories Division

Illinois Clay Products Co., Goose Lake, Ill.
General Refractories Co., Joliet, Ill.
Harbison-Walker Refractories Co., East Chicago, Ind.
Chicago Retort & Fire Brick Co., Ottawa, Ill.
Chicago Fire Brick Co., Ottawa, Ill.

Ladies and General Trips (Local)

Marshall Field & Co.
Adler Planetarium
Shedd Aquarium
Field Museum
Chicago Historical Society
Museum of Science and Industry
Western Electric Co. (manufacture of telephones)
Chicago Tribune
Brookfield Zoo
NBC Studios

H. D. Chase

GENERAL MEETING AMERICAN CERAMIC SOCIETY

Hotel Saint Francis, August 6–12, 1939

San Francisco Fair Will Feature Glass

Various competitions for the exploitation of glass, combined with technical development by the large glass firms of the United States and greater preoccupation with glass as a medium of construction, are making glass an important element in home building of today. The Golden Gate International Exposition, furthermore, is planning to assist in educating the public to the beauty and usefulness of glass.

Although the main exhibition palaces on Treasure Island are built of wood and plaster, without windows, there are a number of fine modern concession buildings which are featuring glass in their construction, not only glass brick but many phases of new plate glass, such as the "Venetian-blind" modeling in the plate glass of Libbey-Owens-Ford Glass Company.

Outstanding will be such buildings as the Pacific House, theme building of the Exposition with its 60-foot elliptical steel sash window; the Yerba Buena Women's Clubhouse, chief hospitality center of the Fair, with two-story glass panel windows to give unobstructed views of the island; the Argentine government building with one entire end, from floor to roof, of glass; and the Owl Drug Company store, which will feature a structural glass front, tall glass columns with internal grid-tube lighting, and opal glass ornamental fountains. Among the exhibitors, unusual glass displays are being planned by Libbey-Owens-Ford Glass Co., Owens-Illinois Pacific Coast Co., and the Kerr Glass Manufacturing Co.

Glass in Model Homes Tour

The use of glass in home construction and decoration will be stressed in the Exposition Model Homes Tour. These homes are being built in the five San Francisco Bay counties, and are sponsored by the Chambers of Commerce of the cities involved, the real estate boards, the banks, the large utilities, gas and electric appliance industries, and the lumber, cement, glass, and paint industries. The object of the tour is to provide an interesting and educational extension of the Exposition itself, so that visitors to the Fair will be induced to visit the outlying communities of the Bay region. All of these houses have to be architecturally designed, and the designs must be approved by a Board of Architects from the American Institute of Architecture. They will also be properly landscaped and furnished.

These houses will be open to the public from May 1 to September 15, 1939, and, when completed, a Plan Book of all of the houses will be published, showing exteriors and the interiors, with complete information as to building materials and costs.

Because of the emphasis being placed on modern architecture by most of the architects, a great deal of glass will be used. In fact, in most houses glass will be stressed, not only as a means of providing ample light, but also from a design standpoint; and the attention of the architects is being called to the latest developments in the glass industry, such as the new Libbey-Owens sheet glass.

The houses will range in price from $6000 to $30,000, and there will be at least thirty houses in the Tour. Not only will these houses be designed by the finest architects, but eight of the houses will be sponsored by European nationals, and glass objects of art will be imported to complete the interior decorating picture. Metal and textiles will also be used, but glass, such as the new sculptured glass, decorated glass mirrors, and molded glass, *i.e.*, structural glass of all kinds, will be featured.

In the Applied Arts Section of the Exposition there will be many fine rooms which will feature glass specifically.

REPORT OF NOMINATING COMMITTEES A AND B

Nominating Committees A and B have announced the following report for officers of the American Ceramic Society nominated for 1939–1940:

President: A. I. Andrews, University of Illinois, Urbana, Ill.

Vice-President: J. L. Carruthers, Ohio State University, Columbus, Ohio.

Treasurer: C. Forrest Tefft, Claycraft Company, Columbus, Ohio.

PITTSBURGH SECTION

Erwin Sohn, Standard Sanitary Mfg. Co., Louisville, Ky., addressed members of the Pittsburgh Section on November 8. The meeting was something of a homecoming for Mr. Sohn, who was Chairman of this Section in 1929. Mr. Sohn talked on "Vitreous Enamels on Metals." This was the last meeting before the joint meeting to be held with the Art Division on January 10, 1939.

—D. G. Bennett, *Chairman*

ROSTER CHANGES DURING NOVEMBER*

Personal

Bates, Harry C., Owens-Corning Fiberglas Corp., Newark, Ohio (Corning, N. Y.)

Berry, Herbert G., 121 8th Ave., Sea Cliff, N. Y. (Columbus, Ohio)

Burr, Marion K., 1811 Woodbine Ave., Knoxville, Tenn. (Elgin, Tex.)

Fackt, George P., 2820 Redondo Beach Blvd., Redondo Beach, Calif. (Los Angeles, Calif.)

Fulcher, Gordon S., 219 Raymond St., Chevy Chase Md. (Louisville, Ky.)

Gulick, Chester, Kentucky Tennessee Clay Co., 601 Vincent Blvd., Alliance, Ohio (Trenton, N. J.)

Marsh, Frank L., Apt. 6, 190 Sanders Rd., Buffalo, N. Y. (Medicine Lodge, Kans.)

Rueckel, W. C., Battelle Memorial Institute, 505 King Ave., Columbus, Ohio (Pittsburgh, Pa.)

Singer, Felix, Keramos House, 46, Castlemaine Ave., South Croydon, Surrey, England (Keramos House, 31, Croham Park Ave., South Croydon, Surrey, England)

Teague, Desmond F., New Windsor Hotel, 120 Richelieu, St. Jean, Quebec, Canada (Niagara Falls, Ontario, Canada)

Wilcox, Herman G., 128 W. 9th Ave., Homestead, Pa. (Pittsburgh, Pa.)

* Address in parentheses is the former address.

TWENTY-FIVE DOLLAR CORPORATION MEMBERSHIPS ARE PROFITABLE INVESTMENTS

- Of the $36,353.54 expended up to October 31, 1938, $25,851.03 or 71+% was used on publications.
- Only $10,502.51 was expended on meetings, salaries, and other promotional activities.
- Because these "general expenses" will not vary greatly, it is evident that with each increase in membership income there will be more cash available to expend on publishing reports of original researches and abstracts of ceramic literature.
- The Society's annual budget of expenditures has not varied much from $40,000 since 1921. When membership subscriptions fall off, as they do in depression years, the deficit is met from invested reserves.
- The invested reserve as of October 31, 1938, is $7864.26. The operating profit for 1938 is $1386.35, with all bills paid and one-sixth of the 1938 dues and subscriptions, not yet earned, listed as liabilities. This profit, which amounts to 3.7% of the earned income, will be added to the invested reserve.
- The ceramic industries realize that it is to their advantage to have publications of reports of original researches and abstracts of the world's ceramic technical and scientific literature. When they realize that the American Ceramic Society is managed in a sound business fashion and is the producer of these reports and abstracts, they will consider their support and coöperation as a profitable investment.
- The Society is capable, but it can render service only in proportion to the investments made through it by ceramic corporations.

PAID MEMBERSHIP RECORD

Date of Record	Members		Deferred	Subscriptions	Monthly Sales	Total Circulation
	Personal	Corporation				
December 10, 1936	1452	196				
December 22, 1937	1713	220	12	523	220	2688
November 19, 1938	1801	216	27	584	220	2848

NEW MEMBERS

Corporation

CRONIN CHINA CO., W. Kress Cronin (voter), Minerva, Ohio.
HANCOCK BRICK & TILE CO., J. Leo Child (voter), Findlay, Ohio.
HAWS REFRACTORIES CO., E. E. Slick (voter), 407 Main St., Johnstown, Pa.

Personal

*ATHERTON, CARLTON, 110 W. Tulane Rd., Columbus, Ohio; assistant professor, Ohio State University.
BOWER, JAMES A., 630 Louisiana Ave., Chester, W. Va.; plant engineer, Taylor, Smith & Taylor Co.
CAMPBELL, JAMES B., 17 W. Halley St., Mount Union, Pa.; chemist, Harbison-Walker Refractories Co.
CASH, I., 911 W. 3rd Ave., Stillwater, Okla.
DUPLIN, VICTOR J., JR., 2804 Bellevue Ave., Augusta, Ga.; charge of research laboratory, Babcock & Wilcox Co.
FIELDS, W. H., 1022 N. Prairie Ave., Joliet, Ill.; superintendent, Illinois Clay Products Co.
*FRANK, JOHN N., Sapulpa, Okla.; president, Frankoma Potteries, Inc.
*HARTY, WILLIAM A., Exolon Company, Blasdell, N. Y.; president.
*MULROY, JAMES P., 965 Lafayette Ave., Buffalo, N. Y.

Student

DOUGAN, CHARLES W., Montana School of Mines.
LAWLER, W., Missouri School of Mines.
TURNER, PICKETT, JR., University of North Carolina.
WILLIS, JAMES B., Ohio State University.

* Indicates former member of the Society rejoining.

MEMBERSHIP WORKERS' RECORD

Corporation			
J. L. Child	1	G. S. Diamond	2
Personal			
G. S. Diamond	4	J. W. Hepplewhite	1
A. F. Greaves-Walker	1	C. L. Norton, Jr.	1
F. A. Harvey	1	Office	1
Student			
C. M. Dodd	1	W. W. Kriegel	1
A. F. Greaves-Walker	1	A. S. Watts	1
		Grand Total	**16**

CERAMIC SCHOOL NOTES

UNIVERSITY OF NORTH CAROLINA

On October 4, 1938, the Student Branch of the University of North Carolina, Raleigh Unit, introduced the new student members to the Society and Dr. Greaves-Walker explained its meaning and purposes.

On November 1, the new members were inducted into the Society with a formal initiation, following which a Hallowe'en party was given in their honor. The main feature of the initiation was a clay modeling contest won by C. N. Kimball of Enfield, N. C. He received as a prize a porcelain elephant which was the model for the contest.

The enrolment of the Ceramic Department is larger than ever before, with 71 students, including three graduate students.

J. J. Amero, a graduate of last year's class, was appointed a teaching Fellow in the Department this year.

Dr. Greaves-Walker attended the annual meeting of the National State Boards of Engineering Examiners at Des Moines, Iowa. He also visited the Department of Ceramic Engineering at Iowa State College, and at Rolla, Mo., he addressed the Student Branch of the Missouri School of Mines and Metallurgy and the Missouri Minerals Industries Conference. The subject of the address before the Student Branch was "The Young Engineer's Preparation for a Professional License" and before the Conference, "The Technical Problems of Ceramics."

—J. N. SMITH, JR., *Secretary*

NEW YORK STATE COLLEGE OF CERAMICS

The first meeting of the New York State College of Ceramics Student Branch, American Ceramic Society, was held October 18, 1938.

The officers for 1938–1939 are *President*, Joseph Proe; *Vice-President*, Lucius Washburn; *Secretary*, Martin Dykeman; and *Treasurer*, Julius Siegel.

C. V. Mann, Missouri School of Mines, talked on "The Selection and the Guidance of Engineering Students" and "The Future of the Engineering Profession." Dr. Mann reviewed the progression of engineering education as it entered the United States, its growth, the present status of the student engineers, the influence of inventions upon engineering, the human element in relation to scientific research, and the factors influencing success to the student.

Dr. Mann illustrated his discourse with statistical charts, devised in the Missouri School of Mines, which predicted quite accurately the number of students graduating according to placement tests and also charts which showed for which profession he was best adapted.

In addition to members of the Student Branch, there was a large outside attendance. This practice we wish to encourage because it creates an interest in our work. The members of the Student Branch therefore extend a cordial invitation to any person interested to attend their meetings.

—MARTIN E. DYKEMAN, *Secretary*

PENN STATE SCHOOL NOTES

Student Branch Meetings

The Penn State Student Branch of the American Ceramic Society held a social meeting on September 28. Talks were given by E. C. Henry and N. W. Taylor of the department staff, with several movie films of the western mining country and a number of natural color photographs of Pennsylvania and New England. Cider and doughnuts were absorbed simultaneously.

George Bair, research fellow on glass at the Mellon Institute, Pittsburgh, lectured before the Student Branch, October 31, on his work on by-product utilization in the glass industry. Dr. Bair is an alumnus of Penn State and a former member of the faculty of the Department of Ceramics.

Cabin Party

The staff and graduate students of the Department of Ceramics held a cabin party in Collyer Gap on September 21. One of the features of the entertainment was an imitation by H. M. Davis, S. Zerfoss, E. C. Henry, and W. Weyl of the noise, confusion and general disturbance in the Mineral Industries building on account of current construction activities.

Research on Optical Glass

Alexis G. Pincus, who for the past six years has been with the American Optical Company at Southbridge, Mass., has been assigned by that Company to work at Pennsylvania State College with Professor Weyl on fundamental problems of optical glass. Mr. Pincus is a candidate for the degree of Doctor of Philosophy.

Graduate Seminar

A graduate seminar on beneficiation of nonmetallic minerals is being given by the Department of Ceramics. This is a new and live subject because of the rapidly increasing industrial demand for high-grade products, such as calcite, kaolin, lithium minerals, chromite, magnesite, nepheline syenite, etc. Emphasis is being given to the newer methods of beneficiation, such as magnetic and electrostatic separation and froth flotation. The economic importance of such techniques is great in Pennsylvania, which possesses many deposits of a medium- or low-grade character and yet, because of its geographical situation, has a distinct advantage over territories more distant from large markets. An active research program on froth flotation is being carried on by D. W. McGlashan, instructor in ceramics.

SEVENTH NATIONAL CERAMIC EXHIBITION

SYRACUSE MUSEUM OF FINE ARTS, SYRACUSE, N. Y., OCTOBER 27 TO NOVEMBER 20, 1938

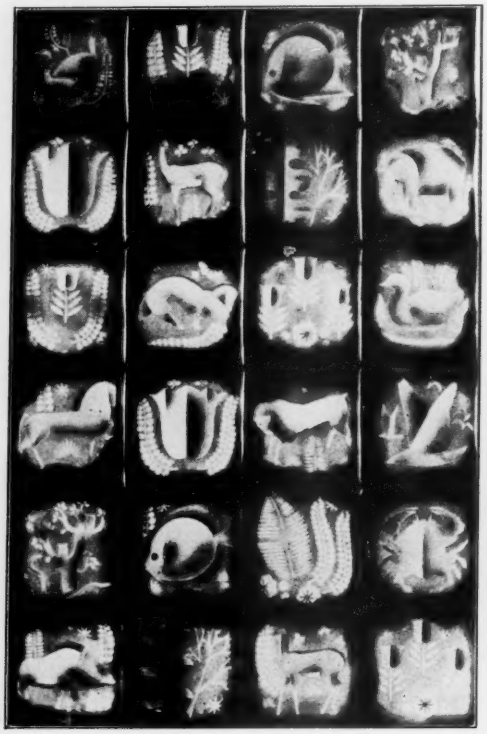
(1) "By the Waterhole," (2) "Glory, Glory," and (3) "The Abduction," by Viktor Schreckengost, Cleveland, Ohio ($100 given by Hanovia Chemical Co., Newark, N. J.).

"Animal Kingdom," enamel panel by H. Edward Winter, Cleveland, Ohio, in group of enamels. First prize for enamels divided with Russell Barnett Aitken of Cleveland, Ohio ($100 given by Ferro Enamel Corp., Cleveland, Ohio).

"Elephant," ceramic sculpture by Paul Bogatay, Columbus, Ohio; honorable mention.

"Cookie jar" of salt-glazed stoneware by Arthur E. Baggs, Professor of Ceramic Art, Ohio State University, Columbus, Ohio; first prize for pottery.

Group of vases by Herbert H. Sanders, San José College, Calif.; second prize for pottery.



ANIMAL KINGDOM, enamel panel by H. Edward Winter.

EXHIBITION CIRCUIT FOR 1938–1939*

University of Minnesota, Minneapolis, Minn., Dec. 1 to 23, 1938.
University of Pittsburgh, Pittsburgh, Pa., Jan. 2 to 23, 1939.
Cincinnati Art Museum, Cincinnati, Ohio, Feb. 1 to 22, 1939.
Memorial Art Gallery, Rochester, N. Y., Mar. 3 to 24, 1939.
American Ceramic Society (Forty-First Annual Meeting), Chicago, Ill., April 16 to 22, 1939.
Columbus Gallery of Fine Arts, Columbus, Ohio, May 1 to 21, 1939.
Currier Gallery of Art, Manchester, N. H., June 1 to 21, 1939.

Donors of Prizes

B. F. Drakenfeld Co., New York, N. Y.
E. I. du Pont de Nemours & Co., Inc., Wilmington, Del.
Ferro Enamel Corp., Cleveland, Ohio.
Hanovia Chemical & Mfg. Co., Newark, N. J.
Onondaga Pottery Co., Syracuse, N. Y.
Katharine Q. Payne Memorial Award.

Jury of Selection and Awards

William M. Milliken, *Chairman;* Director, Cleveland Museum of Art.

R. Guy Cowan, Art Director, Onondaga Pottery Co., representing The American Ceramic Society.

Wayiande Gregory, sculptor, New York, N. Y.

Walter H. Siple, Director, Cincinnati Art Museum.

California Committee: Reginald Poland, Director, San Diego Museum; Roland J. McKinney, Director, American painting, Golden Gate International Exposition.

* The annual National Ceramic Exhibition was founded in 1932 in memory of Adelaide Alsop Robineau.

ELEPHANT, Ceramic Sculpture by Paul Bogatay.

COOKIE JAR, of salt-glazed stoneware by Arthur E. Baggs, Professor of Ceramic Art, Ohio State University.

Viktor Schreckengost, winner of sculpture first prize.

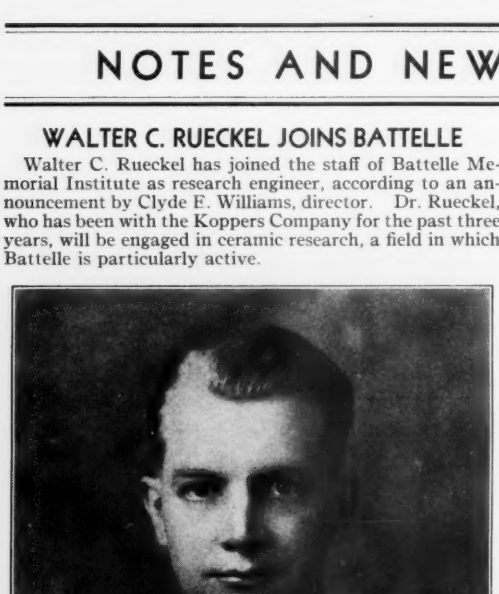
Group of vases by Herbert H. Sanders, San José College, Calif., second prize for pottery.

(1) BY THE WATERHOLE, (2) GLORY, GLORY, (3) THE ABDUCTION, by Viktor Schreckengost.

NOTES AND NEWS FOR CERAMISTS

WALTER C. RUECKEL JOINS BATTELLE

Walter C. Rueckel has joined the staff of Battelle Memorial Institute as research engineer, according to an announcement by Clyde E. Williams, director. Dr. Rueckel, who has been with the Koppers Company for the past three years, will be engaged in ceramic research, a field in which Battelle is particularly active.



Walter C. Rueckel

A graduate of Ohio State University in 1929, Dr. Rueckel for four years was research engineer at the O.S.U. Engineering Experiment Station, being engaged during that period on the development of a de-airing process for brick manufacture, a study of the wear of metals in the ceramic industry, and a variety of other projects. In 1933, he received the degree of Ph.D. from Ohio State University.

For two years Dr. Rueckel was director of the Research Bureau of the National Paving Brick Association, which at that time was working on the development of non-exuding fillers, all-brick pavings, and other technical problems of the industry.

In 1935, he joined the Engineering and Construction Division of the Koppers Company. His work there brought him in close contact with the technical problems of the coke industry and related phases of iron and steel manufacture. He devoted considerable time to research on refractories, the combustion of gaseous fuels, and furnace design.

Earlier associations in the ceramic industry included plant work for plate glass and vitreous enameling companies.

Dr. Rueckel is a member of the American Ceramic Society and has taken an active part in its various divisions. During the past three years he has been Chairman of the Section on Refractory Insulation of the Refractories Committee and a member of the Brick Committee of the American Society for Testing Materials. He is a member of Sigma Xi, Tau Beta Pi, and Keramos.

Dr. Rueckel is the author of numerous bulletins, technical papers, and articles on ceramic research, including studies of properties of glass, enamels, brick manufacturing processes, insulating refractories, electrical porcelains, jointing materials, brick pavings, and coke-oven wall failures.

JOHN N. FRANK SUFFERS LOSS OF PLANT

On the morning of November 11, the Frankoma Potteries, Inc., Sapulpa, Okla., was completely wiped out by fire. All of the molds, master molds, machinery, and equipment were destroyed. The factory will sustain about a $40,000 loss. The only thing that was saved was the office and sales room, which was in a separate building. The plant was producing approximately 17,000 pieces per month.

This came in a bad time, when the men were rushing to finish their fall Christmas orders and get out the spring pieces. Mr. Frank writes that this was a blow "below the belt" and very discouraging, but plans are being made to rebuild immediately.

HENRY JEWETT GREENE REPORTS BUSINESS BOOMING

Henry Jewett Greene, Green Top, Petersham, Mass., writes that "this pottery hobby is an obsession with us; after seven years we are gaining strength.

"The Worcester Art Museum has just complimented us by putting on a show of two cases of our pots, which pleases us a lot."

The Worcester Art School visited the Pottery in November.

Mr. Greene is scheduled to address members of the Art Division at their next meeting on January 10, 1939, in Pittsburgh, Pa. He will bring samples of his pottery ware and will show a movie film of the work at his Pottery.

POTTERS' ROUND TABLE ORGANIZED IN BALTIMORE*

Approximately thirty potters, called together by Mildred L. Clegg, have organized a Potters' Round Table of the Maryland Chapter of the American Artists' Professional League. The meeting was held at the first chapter house of the League, 326 North Charles Street.

Camilla Gardner was made chairman of the organization, which will meet at the chapter house the first Wednesday in each month for discussion of problems related to pottery. "Glazes" will be the subject for discussion in December.

Short talks were given by Walter A. Weldon and N. V. Raghunath of India. The latter has been sent by the Government of Mysore to make a study of ceramics in America.

CANADIAN CERAMIC SOCIETY FALL MEETING

The 1938 Fall Meeting of the Canadian Ceramic Society was held at the Engineers' Club, Toronto, Canada, on November 14, 1938. After dinner, the following papers were presented:

(1) "Sources of Enamel Shop Waste," by W. F. Findlay, Findlay Brothers, Ltd., Carleton Place, Ont.

(2) "Slag Wool," by Harold A. Bevens, Insulation, Ltd., Toronto.

An executive meeting preceded the dinner.

—GORDON C. KEITH, *Secretary*

EASTERN ENAMELERS' CLUB

A meeting of the Eastern Enamelers' Club was held at the Park Central Hotel, New York, N. Y., on December 3, 1938. The following program was presented:

(1) "Enameling: Here, There, Now and Then," by Robert Weaver, President, Ferro Enamel Corp, Cleveland, Ohio.

(2) "Tearing of Cover-Coat Enamels," by Perry Bartlett, Röhm & Haas Co., Philadelphia, Pa.

(3) "Steel: Man's Servant," a technicolor sound film presentation of the Carnegie-Illinois Steel Corp. by Parker H. Van Pelt, Carnegie-Illinois Steel Corp., Pittsburgh, Pa.

Mr. Weaver's address was of particular interest to all members because of his broad experience in the enamel industry. He compared American and European enameling practice and showed some of his collection of antique jewelry enamels.

Dinner was served to the club members in the Cocoanut Grove of the Hotel.

* From the *Baltimore Sun*, Nov. 19, 1938.

A.I.M.M.E. OPEN-HEARTH EXECUTIVE COMMITTEE

At the fall meeting of the Open-Hearth Executive Committee of the A.I.M.M.E. in Detroit, a favorable comment was made on the summer meeting of the Refractories Division of the American Ceramic Society held at Bedford Springs, September 2 and 3, and it was proposed by several members that the Open-Hearth Committee should extend an invitation to the Refractories Division to attend the Refractories Session of the National Open-Hearth Organization to be held Thursday, April 27, 1939, at Cleveland, Ohio.

In the past, refractories manufacturers have been represented by a few technical men and a large number of salesmen and brick "peddlers." It is the endeavor of this meeting to provide a more or less joint discussion between open-hearth operators and refractories manufacturers on mutual problems.

Gilbert Soler, Timken Roller Bearing Co., Canton, Ohio, was named the chairman of the Thursday morning session of the meeting on Refractories, with W. C. Kitto as vice-chairman.

—GILBERT SOLER

FORSTERITE BULLETIN ISSUED

The Engineering Experiment Station, State College Unit of the University of North Carolina, Raleigh, N. C., has issued *Bulletin*, No. 16, "The Production of Unfired and Fired Forsterite Refractories from North Carolina Dunites" by A. F. Greaves-Walker and R. L. Stone. The bulletin covers the occurrence and properties of olivine, the thermochemical reactions which occur in the conversion of olivine to forsterite, and the mixes suitable for the manufacture of forsterite refractories.

USES FOR LITHIUM

A few years ago, the supplies of commercially available lithium in the United States were deemed small and widely scattered, and only limited use was made of this, the lightest metal known. The mineral technologists of the United States Bureau of Mines, realizing the importance of increasing this supply and of expanding the technologic applications, have resurveyed the sources of low-grade lithium ores in the United States and have developed a method of concentrating and extracting lithium compounds from spodumene (lithium feldspar). The surveys and developments have proved so successful that lithium is regarded as one of the cheaper readily available metals. This has increased the potential field of use, which now extends to the air-conditioning field, where a 65% solution of lithium chloride has proved an excellent dehumidifying agent; to glass technology, where lithium oxide as a constituent gives desirable optical and other properties; to the ceramic industry, where the lithium compounds have shown valuable properties as in fluxing, vitrification, and bonding; and to many other industrial applications.

This story of lithium was told by Frank Hess, principal mineralogist of the Bureau of Mines, in the first lecture in the University of Maryland-Bureau of Mines lecture series on October 25, 1938, at College Park, Maryland.

NEW GLASS TEXTILES MANUFACTURED

The Owens-Illinois Glass Company and Corning Glass Works have announced the formation of Owens-Corning Fiberglas Corporation, which will produce a variety of products made from fiber glass. As a result of the extensive research facilities of these two companies, the products to be manufactured by the new corporation are said to promise revolutionary developments in many fields of insulation, construction, and industrial design. It marks the culmination of development work by the two companies involving expenditures totaling about five million dollars.

Games Slayter, who is credited with having played the major part in the development of this new basic product, is vice-president.

EDWARD ORTON MEMORIAL

Dedication of a monument with a bronze memorial plaque honoring Edward Orton (first president of Ohio State University and former Antioch College president), erected in a grove of maple trees near Clifton, Ohio, took place on October 26, 1938. Donor of the monument, a 25-foot polished granite shaft, was Hugh T. Birch, Antioch alumnus, who has given hundreds of acres of land to Bryan State Park, near Yellow Springs, and to the College, including a site and monument to Horace Mann.

The inscription on the plaque, below a bust in relief of Professor Orton, the work of Amos Mazzolini, modeling instructor at Antioch, was written by Mr. Birch and reads as follows:

"He loved the youth of the land and inspired them to seek education. He taught them to build a soul. He advocated the beautiful religion of Jesus Christ. Especially did he inspire them with a love for nature. He implored them to uphold with staunch citizenship their country as founded by Washington, Jefferson, Horace Mann, and Abraham Lincoln."

Memorial to Edward Orton at Antioch, Ohio

The plaque is of heroic size and, to make the features as accurate as possible, Mazzolini studied models at Ohio State University and interviewed Professor Orton's daughter at Columbus.

Mr. Birch was a student at Antioch when Professor Orton was geology instructor there and was inspired to perpetuate his memory in a memorial on a donated tract known as Orton Park. The monument weighs twenty-two tons. Trees in the maple grove were rejuvenated by Mr. Birch at a cost of several thousand dollars.

Professor Orton served as Antioch president in 1872. The following year he was appointed President of Ohio State University, serving in that capacity until 1881. He died in 1899 at the age of seventy years.

The dedicatory address was presented by Professor Swinnerton, geologist of Antioch College, who writes as follows:

"The print does not give an adequate impression of the size of the monument—the shaft is more than twenty feet high and the maple trees forming the background are really magnificent trees. The arrangements for the dedication have been taken over by Dr. Edmond Secrist, Director of the State Agricultural Station at Wooster, Ohio, and O. A. Alderman, who are immediate supervising officials of the State parks. Dr. Swinnerton's theme was 'Edward Orton, the Interpreter of His Chosen Science, Geology, Rather Than the Innovator.'"

Mr. Birch, the donor of the monument, is an old man now, but he is hale and hearty and has been a most generous friend to Antioch. It was more than seventy years ago that he had his contacts with Edward Orton, yet he remembers them very vividly and feels that they made an indelible impression on his character.

Ten years ago he gave a beautiful glen to Antioch College to be called "Glen Helen" in memory of a daughter he lost.

Although Edward Orton passed away nearly forty years ago, his memory is kept alive at Ohio State University by the building on the campus known as Orton Hall and also by the magnificent geology library which was dedicated to his memory by his son, Edward Orton, Jr.

BUREAU OF MINES LECTURES

On Tuesday, January 24, 1939, Hewitt Wilson will give a lecture at the Bureau of Mines Station under the auspices of the University of Maryland, College of Engineering, College Park, Md. His title will be "Old and New Uses for the Rocks in the Southern Appalachian State."

These lectures will be continued throughout the university year. Succeeding speakers will be outstanding members of the staff of the Bureau of Mines, selected because of broad and varied experience in fields of wide technical and public interest, involving fundamental and pioneering research. Although the lectures are arranged in connection with the new work of the University in chemical engineering, they cover a broad field of science, technology, and economics.

WPA PUBLISHES SUMMARY AND INDEX OF RESEARCH

The results of some two thousand research projects carried on as part of the federal work relief program are summarized briefly in a digest and index which has been published by the Works Progress Administration. This volume of 291 pages contains a concise statement of the principal conclusions of each study and an alphabetical subject index to the contents. The reports on these projects touch upon nearly every field of natural and social science, and many of them have appeared in the form of articles in scholarly journals. Several hundred of the reports summarized in this index, however, are in manuscript form, and arrangements have been made with the American Documentation Institute whereby microfilm copies of the original reports will be furnished at nominal rates for the use of research specialists. A small edition of this volume has been prepared for distribution to the larger public and university libraries, where it will be available for reference, and for government departments, industrial concerns, and research foundations. A limited supply of copies of this Index of Research Projects is still available. Requests should be addressed to the Works Progress Administration in Washington, D. C.

BATTELLE MEMORIAL INSTITUTE FELLOWSHIPS

Two engineers have been appointed to Battelle research fellowships in the graduate school of Ohio State University. Jack Anthony Nachowitz, a mechanical engineering graduate of the University of Illinois has received a fellowship in metallurgy, and Sidney J. Brooks, a graduate of the ceramic engineering department of Ohio State University, has been appointed to a fellowship in ceramics.

Mr. Brooks is to investigate the effects of various vitrifying agents upon the physical properties of wall-tile bodies, and Mr. Nachowitz is to make a study of the coloration possibilities of metals and alloys.

AN OPPORTUNITY TO PROMOTE CERAMICS*

Talking Pictures to Dramatize Industry

The Department of Commerce has been asked to sponsor and provide national distribution for a series of talking pictures dramatizing the aims, processes, achievements, and ideals of American industry under democracy.

Secretary Roper expressed his willingness to have the Department undertake this service for American business and invited Thomas J. Watson to call together a group of representative industrial leaders to discuss the merits of this plan.

Under the plan proposed, each industry would supply a feature film, not to exceed four reels in length, dramatizing the history, processes, achievements, and ideals of that industry and its contribution to national development. These films would be devoid of direct advertising for any individual firm but would necessarily embrace the industry as a whole.

James T. Shotwell of Columbia University, a well-known historian, has consented to act with Dr. Studebaker, Herbert S. Houston, and others, as a committee to work with the writers of the scenarios to make this library of films a true historical and inspiring record of American achievement under private initiative and democracy.

The committee which met with Mr. Watson unanimously endorsed this general plan, following discussions participated in by Dr. Shotwell and Dr. Studebaker.

Under this general plan, the Department of Commerce would supply sponsorship for the films and an organized system of distribution, a system which does not now exist for films of this character. The U. S. Chamber of Commerce would coöperate by helping to assist its 1200 affiliated Chambers of Commerce in setting up local machinery in each city for the wide showing of these films. Dr. Studebaker told the committee that the creation of such a library of truly educational industrial films would stimulate the installation of projectors in the schools so as to make these pictures available to twenty million school children. The San Francisco Exposition has agreed to run them in the Federal theater there and the matter is being considered favorably by the New York World's Fair. The National Grange and other national organizations have indicated coöperation in this distribution effort. The Department of Commerce would supply these films for free exhibition in the schools and elsewhere. Production would be assigned to reputable existing producers of industrial pictures.

The Department of Commerce feels that these films would also be useful in foreign lands to stimulate business for American firms.

—Frank R. Wilson, *Assistant to the Secretary*
Department of Commerce,
Washington, D. C.

Atlas Educational Film Company Available

C. A. Rehm, Secretary of the Atlas Educational Film Co., has notified the Secretary of the Society that his Company will advise and assist members who are interested in issuing films depicting their industries. He states that members will incur no obligation by asking advice. The Company is located at Oak Park, Ill.

OHIO CERAMIC INDUSTRIES ASSOCIATION

Paving Brick Division Meeting

This meeting was held October 27, 1938, at the plant of the Hocking Valley Brick Co., Logan, Ohio. Following a plant inspection and luncheon, motion pictures were shown of the recently laid reinforced brick section on State Route 23 north of Delaware. H. Z. Schofield, Research Director of the National Paving Brick Association, whose work is being done at the Engineering Experiment Station, Ohio State University, was in charge of this part of the program.

* Letter dated September 14, 1938.

RARE AND UNUSUAL GLASSWARE TO BE SHOWN IN GLASS CENTER AT WORLD'S FAIR

The actual manufacture of glassware and the unique and odd usages of glass in everyday life will be featured in the Glass Center exhibit at the New York World's Fair, 1939. The many uses to which glass is put in the hotel, restaurant, and allied fields will be an important part of the display. The Glass Center will be constructed primarily of glass and will house the combined exhibits of the Corning Glass Works, Owens-Illinois Glass Co., and Pittsburgh Plate Glass Co. Close to the thematic Trylon and Perisphere, the Glass Center will be on the Avenue of Pioneers in the heart of the fair-grounds. The 108-foot tower will be constructed of blue plate glass and glass block. A hot glass furnace and a fiber-making machine in actual operation will be among other highlights of the exhibit.

STUDY HOURS ON COLOR AND DESIGN AT THE METROPOLITAN MUSEUM OF ART*

The Sunday and week-day courses of demonstration lectures and gallery talks grouped under the general title, "Study Hours on Color and Design," for the season 1938–1939 will comprise courses for the public, for members of the Museum, and for teachers of the city.

Guest speakers Sunday afternoons at three o'clock will include the following: Joseph Hudnut, A.I.A., dean of the School of Design, Harvard University, will lecture on "Design in Architecture"; Harvey Wiley Corbett, F.A.I.A., president of the New York School of Applied Design for Women, on "Design in Tall Buildings"; Talbot F. Hamlin, A.I.A., Avery librarian, Columbia University, will give two lectures on "American Small House Design," in which the English, French, Italian, and Spanish types will be reviewed; Aymar Embury, II, consulting architect of the Department of Parks, New York, will give two lectures on "The Early American House," in which English, Dutch, and other types will be treated; and William Lescaze, A.I.A., wil give the concluding lecture of this group on "American Houses, Modern Types."

Miss Grace Cornell of the Museum staff will introduce the subject of "Interior Design" with three talks, in which styles and periods and the furnishing of the small house and apartment will be considered. Other lectures on interior design will be given by Francis K. Lenygon, president of the American Institute of Decorators, who will speak on "Architectural Backgrounds," and Edward Warwick, principal of the Philadelphia Museum School of Industrial Art, whose subject is "Furniture Design." The first lecture in a group entitled "Modern Materials of Decoration" will be presented by Eugene Schoen, A.I.A. The other speakers will be Walter Kantack, President of Kantack and Company, on "Design in Metal"; Leon V. Solon, Secretary of The Architectural League of New York, on "Modern Design in Clay"; and Frank Sohn, designer for the Libbey-Owens-Ford Glass Company, on "Modern Design in Glass."

Public courses will also be given on Tuesdays and Thursdays. "Color Study," the elements of color and its use in various styles of design, will be presented in the Tuesday morning series. This course has been subdivided into three groups: (1) color facts, (2) color in interior design, and (3) the painter's use of color. These groups made up of five, four, and eight lectures and gallery talks, respectively, may be taken independently. The Tuesday afternoon series, devoted entirely to "Interior Design," will offer a survey of decorative treatments in many styles, including those of the present day.

A special series, "Short Courses on Design and Color," will be offered on Thursday afternoons. These courses, planned particularly for persons who have limited time for Museum study, consist of four lectures each, *viz.*, (1) Italian decorative art, (2) French decorative art, and (3) English decorative art.

* Reprinted with permission from the *Bulletin of the Metropolitan Museum of Art.*

CLAY EXHIBITS AT COOPER UNION MUSEUM

Nearly two hundred art objects, ranging in date from the earliest dynasties of ancient Egypt to the present and depicting "Baked Clay in the Service of Man," are on view at the Cooper Union Museum for the Arts of Decoration. The exhibits, many of them rare and never before publicly displayed, symbolize clay as an instrument of progress in science, art, and social philosophy, the three-fold educational interest of Cooper Union.

Egyptian and Mesopotamian vases and religious figurines, jars from China, plates and teacups from all the countries of Europe and from Mexico and South America, and modern decorative ware made in the United States have been assembled from Cooper Union's own pieces and through loans from forty-five leading museums and art collectors throughout the country.

Each item of the display is symbolic of a stage in the growth of the clay industry from its origin centuries ago as "woman's work" to its development today as a 300 million dollar industry in the United States alone.

"Man's mastery of the basic materials of civilization is the result of countless trials and many errors," according to Mary S. M. Gibson, curator. "In articles of baked clay, this record is preserved with a completeness not obtainable in any other material. Documented here is the whole trend of man's progress from the accidental to the deliberate and sure.

"In its easy workability and unlimited possibilities for harmonizing form, color, and decoration, clay, which has provided so many articles of utility, has made a distinct place for itself in the arts of sculpture, architecture, and interior decoration.

"In its growth from a woman's craft in Neolithic times to a major industry of the present day, baked clay has had a profound effect upon man's thought and behavior. In ways too numerous to mention, this material contributes daily to our well-being, sharing with textiles, metals, and wood the distinction of being one of the prime materials in the maintenance of our culture."

The social importance of baked clay is represented by eight objects. An Egyptian bowl of polished redware, the work of Egyptian women, dates from before 3200 B.C. (it is loaned by the Metropolitan Museum of Art). A wheel-made redware vase from ancient Babylonia indicates the division of labor which followed the introduction of this mechanical device, pottery becoming man's work rather than woman's. The vase, about eight inches high, has incised decorations, and was brought from the Near East by the University of Pennsylvania Expedition of 1938. A seated funerary figure from the Zapotec area of southern Mexico dating from about the A.D. 15th Century loaned by the American Museum of Natural History, represents the ceremonial use of clay.

A Persian rosewater sprinkler made in China indicates the impetus given to trade after the invention of porcelain. The sprinkler, which consists of a bowl with a perforated top supported by six curved arms, is of gray porcelain decorated in blue, and dates from the 16th Century.

A drug jar of majolica ware from Italy portrays the rise of pottery making as an industry, which came about first in Italy and which brought in its wake the organization of trade unions. The drug jar, loaned by the Philadelphia Museum of Art, is decorated with the figure of a man.

As an example of the first true porcelain made in Europe, a tea caddy of glazed white porcelain made by Johann Friedrich Boettger about 1715 in Meissen, Germany, is shown. The caddy was copied by molding from a Chinese original. About six inches high, it has six sides with Chinese trees and birds in low relief. It was Boettger who brought the ceramic art of Europe to its maturity.

A Wedgwood butter dish of the famous blue and white jasper ware traces the development further, for Josiah Wedgwood applied the factory system to the manufacture of his ware, thus reducing costs and increasing output.

A porcelain whiteware glazed insulator for electric wires, symbolic of present-day civilization, completes the group, suggesting the development of baked clay as a major modern industry.

A second section of the division emphasizing the social importance of baked clay is devoted to the development of two important materials, glass and enamel, and of two techniques, turning and molding. Both materials and techniques have now been transferred to other industries, it is pointed out, and stand independent of clay.

Glass, which originated as glaze on stone, is shown in three stages: an Egyptian kohl jar of glaze on slate, an Egyptian canopic jar from about 1400 B.C. made of faience, or artificial clay, and a large flask of Pyrex-brand glass used in today's chemical industries. The development of enamel is symbolized by a Babylonian wall nail and a circular plaque by H. Edward Winter, contemporary artist. The wall nail, on which traces of enamel still show, is about 4 by 2 inches and was used as an ornament on the walls of buildings of sun-dried brick. The plaque has shadings of blue, green, and orange enamel on copper.

An Egyptian polished red pot, dating from about 1600 B.C., is contrasted with a stainless steel bowl and an aluminum tray, both of spun metal, to picture the advance of the art of wheel turning. Progress in the use of the mold is reflected in a sun-dried clay brick from ancient Egypt, bearing a royal stamp, and several knife handles molded of modern plastic.

A three-dimensional model, made and lent by the Massachusetts Institute of Technology, depicts a pottery in New England about 1800, and represents an early stage of an industry which has grown in the United States to a point where it now employs more than 100,000 men. The diorama gives a complete view of the pottery, including the horse-driven clay mill for mixing clay with water, the potter's wheel being operated by the owner, and the ware ready for baking in the kiln.

More than half of the items in the showing are included in the division devoted to science, where "man's mastery over material" is set forth by diagram and by artistic examples. The diagram indicates the four processes, kneading, shaping, drying, and firing, necessary to change clay from a lump of raw material to a vessel pleasing in form and proportion. Mineral substances, which are essential ingredients of clays and glazes and the ultimate sources of pigments used for coloring glazes, are displayed.

Outstanding among the pieces which show the gradual increase in proficiency in the production of clay products is a corrugated and incised vase from Tepe Gawra, dating from 4200 to 4100 B.C., and lent by the Museum of the University of Pennsylvania. The vase, which has never before been exhibited, is one of the only two known examples of its kind, the other being in India. It is unglazed porous pottery, showing a technical proficiency in shaping and decorating.

Another extremely rare object is a female figurine found at the lowest level of Tepe Gawra excavations. About two inches high, it is well formed and was probably a cult object. Its significance lies in the association of the sculptured form with other objects of utilitarian form dating from the same period. The figurine, also lent by the University of Pennsylvania Museum, is exhibited for the first time.

Small greenish wall tile from Sakkara, Egypt, about 2800 B.C., are among the earliest definitely dated objects illustrating the use of glaze.

There is a Hispano-Moresque plate of brown luster ware, loaned by the Philadelphia Museum of Art, and a Rhages bowl of the same ware from the Metropolitan Museum of Art. There is a tin-enameled clay Iranian bowl decorated with small figures, which, as one of the earliest of its kind, has great archeological importance. Found in Tabriz, Persia, it is the first definite evidence of the migration of pottery painters from ancient Kashan, in Persia, to Tabriz in the first half of the 14th Century.

Other stages of development are indicated by French, Dutch, and English faience, and by representative pieces of German, English, and Chinese stoneware. Among these is a vase of the Sung period in China from the collection of

Warren E. Cox and several plates of Wedgwood and Leeds ware from the Cooper Union Museum collection.

Among the hard and soft paste porcelains from all sections of Europe is an early Meissen, Germany, tea service of white with gold Chinoiserie decoration. The French Institute has lent a rose Pompadour plate said to be extremely rare. The rose Pompadour ware was made at Sèvres, France, between 1753 and 1763, and has never since been duplicated. Gold was mixed with rose to obtain the unusual color. Most of the ware was in the possession of Madame de Pompadour and disappeared after her death.

The acme of baked clayware is represented by a large Chinese vase of the Ming dynasty. Colored in a shade of delicate red, known as "peach bloom," the vase has enameled decoration representing "three immortals descending on clouds to a palace floating among waves." Gold is used for emphasis on the robes of the immortals. It is the only enamel-decorated vase with a red ground recorded in any collection, and was loaned by Warren E. Cox.

The third division of the exhibition, concentrating on modern pieces, reflects the current widespread interest in ceramic art. It includes pottery, decorative ware, and modern sculpture. Contemporary potters represented by their works are Arthur Baggs and Harold Reigger, Ohio State University; Maija Grotell, Cranbrook Academy; Helen Clark Phillips and Martha Davis, New York City; Glen Lukens, Los Angeles, Calif.; William Soini, Brooklyn; Dorothea Warren O'Hara, Darien, Conn.; Harriette Miller, Arlington, Vt., and the late Anita Linzee and Adelaide Robineau.

A baby's head of unglazed porcelain by Paul Jeenewein of New York City, a terra cotta duck by Carl Walters of Woodstock, N. Y., a statuette of "Moses" by Alexander Blazys of Cleveland, the "Arabian" by Alexander Archipenko of New York City, and a "Native Woman and Child" by Paul Bogatay of Columbus are included in the sculpture group.

The exhibition, which will continue until January 7, will be open to the public daily except Sunday, and evenings from Monday to Friday.

Lenders to the Baked Clay Exhibition follow: American Museum of Natural History, Arthur E. Baggs, Alexander Blazys, Paul Bogatay, Brooklyn Museum, Catalin Corp. of America, Mr. and Mrs. DeWitt Clinton Cohen, Consolidated Edison Co. of New York, Warren E. Cox, Martha Davis, B. F. Drakenfeld & Co., Federal Seaboard Terra Cotta Corp., Ferargil Galleries, French Institute in the U. S., and Ginsberg and Levy, Inc.

Miss Maija Grotell, Mrs. Montgomery Hare, Mrs. Nina Hatfield, Charles Bain Hoyt, Edward G. Kent, Koopman Antiques, Fahim Kouchakji, C. W. Kraushaar Art Galleries, Lenox, Inc., Mrs. Luke Vincent Lockwood, Massachusetts Institute of Technology, Mr. and Mrs. George B. McClellan, Metropolitan Museum of Art, D. and A. Milch Art Gallery, Newark Museum, Mrs. Robert B. Noyes, Parish-Watson & Company, Inc., Philadelphia Museum of Art.

Mrs. Helen Clark Phillips, Mr. and Mrs. Arthur Upham Pope, Rehn Galleries, Harold Reigger, Nelson A. Rockefeller, Shearwater Pottery, William Soini, Syracuse Museum of Fine Arts, University of Pennsylvania Museum, Miss Edith Wetmore, H. Edward Winter, and Wright Accessories, Inc.

HISTORY OF GLASS INDUSTRY AT NEW YORK WORLD'S FAIR

The Glass Center building proper will occupy an area of 25,000 sq. ft., describing a huge semicircle over the 57,000 sq. ft. on which Glass, Incorporated, the joint exhibiting company, will build. In contrast to many other Fair buildings, Glass Center is being constructed primarily of glass block, plate glass, and structural glass, with a definite view toward permanency. The important position occupied by glass in modern construction will be exemplified fully in the erection of Glass Center.

America's *oldest industry* will be traced from its inception down through the ages and into a vivid presentation of what part glass may be expected to play in the "world of tomorrow."

Glass Center at New York World's Fair (for a notice of the dedication ceremonies see the *October Bulletin*, page 431).

COMMUNICATIONS—CERAMIC HISTORY

HEINRICH RIES

The American Ceramic Society is taking this opportunity to pay tribute to Heinrich Ries, Professor of Geology, Cornell University. Dr. Ries is one of nine surviving Charter Members of the American Ceramic Society.

A letter was sent to Dr. Ries requesting biographical material. The letter was received just as he was leaving Ithaca, New York, and the following note was written on the train on August 22, 1937:

"Unfortunately I can not say that I was one of a family of twelve, or that I was brought up in a log cabin on a farm.

"All that I can say is that natural science seemed to have a fascination for me from childhood up. I got 'stuck in clay' purely by accident, for when, at the end of my junior year in college, I applied to the New York State Geologist for a summer job, he told me to examine and report on the Hudson River clays. When I started out I wasn't sure whether I knew the difference between a brick and a china plate. I did my field work during the day, however, and read up on clays in the evenings. I guess the State Geologist was satisfied with my report because the next year he told me to go on and cover the entire state. And so, when I finished New York, I got work with other state surveys in successive years until I had covered quite a few states and the whole of Canada.

"In 1897, when I held the Barnard Fellowship from Columbia, I went over to Berlin to study clays in Professor Witts' laboratory. Stanley Burt had previously been there and had recommended it to me. While abroad, I took occasion to visit all the well-known clay deposits that I could and also a number of the clayworking plants.

"From this, you will see that there is nothing picturesque or dramatic in my 'clay history.' "

Dr. Ries also states, in a letter of later date, that the "task of putting down biographical facts about myself requires me to put my inborn modesty temporarily in a pigeon hole."

Heinrich Ries was born April 30, 1871, in Brooklyn, N. Y., the son of Heinrich Ries and Caroline Bowman (Atkins) Ries.

He received the following degrees from Columbia University: Ph.B., School of Mines, 1892; A.M., School of Pure Science, 1894; and Ph.D., 1896. From 1893 to 1895, he was a fellow in mineralogy at Columbia University, and from 1897 to 1900, a Barnard Fellow. He was a lecturer in the New York City public schools in the winters of 1895 to 1897, and an assistant in mineralogy at Columbia University from 1896 to 1897. From 1898 to 1902, Dr. Ries was instructor in economic geology at Cornell University; from 1902 to 1906, he was assistant professor; and from 1906 to the present time he has been professor of geology, and from 1914 to the present time, head of the geology department.

Survey Positions

Dr. Ries was assistant geologist for the New York Geological Survey in the summers of 1891, 1892, and 1895; in the autumn of 1895 he was associated with the North Carolina Geological Survey. He also worked with the following surveys during the summer vacations: Maryland, 1897; Alabama, 1898; Michigan, 1899 and 1906; New Jersey, 1900 and 1901; Texas, 1903; Wisconsin, 1904; Virginia, 1905, 1916, and 1922; Canada, 1909 to 1913; and Kentucky, 1923.

Offices

He was a member of the Board of Managers, A.I.M.-M.E., from 1902 to 1905, and chairman of the Committee on Nonmetallic Minerals, 1910 to 1926; vice-president of the American Ceramic Society from 1903 to 1904 and president from 1910 to 1911; president of Sigma Xi, Cornell chapter, 1911 to 1912; chairman of the Committee on Standard Tests of Sands, American Foundrymen's Association, 1923 to the present time; technical director in charge of sand research for the same Association from 1928 to date; and vice-president of the Geological Society of America in 1926 and president, 1929 to 1930.

Societies

Dr. Ries is a Charter Member and an Honorary Life Fellow of the American Ceramic Society; a Life Fellow, Geological Society of America; Life Member, American Institute of Mining and Metallurgical Engineers and American Geographical Society; Honorary Member, American Foundrymen's Association, Rochester Academy of Science, and the Kentucky Academy of Science; Fellow of the American Association for the Advancement of Science and the American Mineralogical Society; member of the English Ceramic Society, American Association of Petroleum Geologists, Canadian Institute of Mining and Metallurgical Engineers, Society of Economic Geologists, the Seismological Society of America, and the Society of Economic Paleontologists and Mineralogists.

Dr. Ries is also a member of the following honorary societies and fraternities: Sigma Xi, Phi Kappa Phi, Gamma Alpha, and Sigma Gamma Epsilon.

Editorial Positions

Dr. Ries has been associate editor for the American Ceramic Society and the Society of Economic Geologists.

Jury of Awards

He was a member of the jury of awards for the Cotton States Exposition, Atlanta, Ga., 1895; the Pan-American Exposition, Buffalo, N. Y., 1901; and the Louisiana Purchase Exposition, St. Louis, Mo., 1904.

Delegate

Columbia University sent Dr. Ries as a delegate to the International Geological Congress in Russia, 1897; and from Cornell University, he was sent to the same Congress in France, 1900; Mexico, 1906; Canada, 1913; and Washington, 1933.

Medals

The Joseph S. Seaman Gold Medal was presented to Dr. Ries in 1936 by the American Foundrymen's Association, in recognition of his researches on foundry sands and its benefit to the foundry industry.

Dr. Ries presented the Edward Orton, Jr., Memorial Lecture at the Thirty-Seventh Annual Meeting of the American Ceramic Society in Buffalo, N. Y., in 1935.

At the present time, Dr. Ries is Chairman of the Committee on Geological Surveys of the American Ceramic Society and is supervising a compilation of clay definitions.

Publications by H. Ries

The following list contains fifty-five titles out of two hundred which Dr. Ries has published in his still active career:

"Quaternary Deposits of the Hudson River Valley, with Notes on the Brick Clays," *N. Y. State Geologist, 10th Ann. Rept.* (1891).

"Clays of New York," *N. Y. State Museum Bull.*, No. 35 (1900).

"Technology of the Clay Industry," *U. S. Geol. Surv., 16th Ann. Rept.*, Part 4, p. 523 (1894).

"Pottery Industry of the United States," *U. S. Geol. Surv., 17th Ann. Rept.*, Part 3, p. 838 (1895–96).

"Limestones of Eastern New York and Western New England," *ibid.*, p. 795 (1896).

"Monoclinic Pyroxenes of New York State," *N. Y. Acad. Sci.* (*Annal*), p. 124 (1896).

"The Augen Gneiss Area, Pegmatite Veins, and Diorite Dikes, at Bedford, N. Y." (with L. McI. Luquer), *Amer. Geologist*, **28,** 239 (1896).

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CHING THE POTTER*

By John A. Foster

In the golden age of Chinese ceramics, in the Sung dynasty, when pottery was king of the Arts, lived ancient Ching, king of the Potters.

He stood before his kiln, watching perspiring fuel-carriers running endlessly up the ramp to the mouth of the insatiable monster. For the last twenty-four hours of the past three days, it had tried to consume the cedar wood more rapidly than they could feed it.

Ching held in his hand the last trial piece young Chang had but a moment before drawn from the kiln. He examined the glaze with satisfaction. It was starting to flow. He chipped a piece from its edge. The body of the ware was mature. The spirits of fire had been kind to him. He knew his kiln contained good pots, pieces the Emperor would be pleased to behold.

He turned to young Chang, standing eagerly at his side, and smiled. "Stop the firing, Chang. Seal the kiln."

He looked with admiration on Chang as he carried out the order—watched him as he directed the workers to brick up hastily the charging hole. This was done to keep out the air spirits that would rush in and wipe off the highly prized color they had labored so long to attain.

Some day Chang would carry on the work which he could never hope to finish in a lifetime all too short.

* Presented at a meeting of the Art Division held at Dearborn, Mich., October 24–25, 1938.

As Director of the Imperial Kilns, the ancient Ching could now put into practice the wealth of knowledge he had gained during his lifetime experience as a potter. But Chang must share that experience and profit from it. So that night, as they sat in the Palace garden by the lotus pool, he told him the story of his life.

As a young boy, he had gathered wood near his father's farm to feed the fiery monsters in the distant village. He wondered why it must be a particular kind of wood and what would happen if other woods were fed to the monsters. Today he knew why. Knew that it was because there was a difference in the ash from different woods, and wood ash was an important element in the glaze material. He had no laboratory to furnish chemical analyses of his raw materials—no chemist to tell him that the ash from the Oak was high in Calcium—that Beech, Larch, and Fir were the best sources of Potassium, that Mulberry was best for Sodium, and that best of all and most difficult to obtain as a source of the valuable Phosphorus was the ash from Ferns and Grapevines. He knew nothing of these elements. But he did know from many experiments that the fusibility of the glaze—whether it was transparent as crystal or translucent as jade, whether it was crackled coarsely like ice or fine as the mesh of the spider web, whether it was the white of a thousand frosty moons, or the blue of the sky seen through the clouds after rain—depended almost entirely on the kind of ash he used in making his glaze. He knew these things as the result of many disappointments and many more successes, and because as a child he had wondered about the fiery monsters in the village.

When Ching grew older, he was taken by an uncle to a place in the hills where the white clay and the white clay rock were mined. Here he learned the careful manner in which those materials were selected, broken up, washed, and ground in water-powered stamp mills in the spring when the streams were happy and by hand in the fall when they were sad. Thus prepared, these materials were formed into small cakes and transported on rafts down the river to the village.

Several years later he was taken on one of those rafts to another uncle who was a potter in the village. What an experience that was, his first trip there!

Here he saw those same cakes of materials he had prepared in the hills dumped, in certain proportions, into a shallow pit, where, after the addition of water, they were worked into a paste by a bullock that was prodded to a continuous treading of the sticky mass. Later he saw this mass shoveled out and spread on mats in the sun to partially dry.

Then he was taken on and acquainted with the various steps in making the pottery. Most of the houses had a large heavy stone wheel which turned on a spindle set in the floor.

The wheel had a hole in the top near the outside edge; it was fascinating to see the potter insert the point of a long stick and with a few powerful turns set the wheel spinning rapidly. He would then hastily squat on the floor over it and throw a ball of clay in the center and, with deft fingers, instantly transform it into a fine rice bowl.

The bowl was then quickly cut from the wheel with a piece of string and set aside on a board. Another and another ball of clay became a row of rice bowls before the wheel had lost its momentum.

He was told that the best potters could thus fashion as many as ten at a single spinning of the wheel, if the clay was properly tempered and wedged.

At another similar wheel, he saw what next happened to those bowls—saw them placed on it bottom up and a neat foot speedily and carefully turned.

The bowls thus thrown and turned were then taken by another member of the household who, with a few masterful strokes, skilfully etched a sacred lotus design on the inside.

Here a world of possibilities unfolded before the eyes of young Ching. That day his life's work was revealed to him. What more fascinating work could life hold than to feel the plastic clay as it spun on the wheel—as it curled from the turning tool and yielded to the etching point.

Next he was taken to a large building where all the potters brought their ware to be appraised and where they were paid on a basis of quality and quantity. This was an exciting experience, for there was much bickering between the appraisers and the potters as to the value of the pieces.

Here, too, those various pieces were arranged on open shelves where the sun and breeze could thoroughly dry them. During the rainy season and in the winter months, this was a difficult matter, and matting was used to enclose the area and, with the aid of charcoal burners, the drying process was carried out, but never as well as when the weather was fine.

Weather was a very important matter in the potter's experience—so much depended on it—the mining of the clay and clay rock—the drying of the ware—the firing of the kilns—all were affected by it.

In one end of this same building, Ching saw a strange procedure. A man was dipping the dried bowls in a tub of milky liquid. This was the glaze, and the bowls thus coated were set on several small buttons of clay and carefully nested, one within another, inside a round clay box or sagger, to protect them from the direct flames in the kiln.

The sagger thus filled was carried to a hillside a short distance away, where the carrier entered a hole in the bottom end of what seemed to be a giant ground-mole track up the side of the hill.

Looking about, Ching saw many of these mole tracks on the hillside, and from the top end of some of them he could see flames emerging, giving the appearance of serpents breathing fire from their nostrils. There were small holes spaced at regular intervals throughout their length, and men were dropping wood into these holes.

These were the fiery monsters, the kilns, for which he had gathered wood when a child. It was the fire spirit in the wood that made the bowls so hard and melted the glaze stuff to make the shiny glass coating.

Ching smiled as he recalled his bewilderment at the firing process—thought of the enormous losses at some of the kilns where he had worked, and at the price he had paid to achieve his reputation for winning such a high percentage of satisfactory ware.

He thought of the many different kilns he had designed in his mind, but never constructed, lest he discredit his ancestors and incur their displeasure.

It was different now. He was old. The Emperor had commanded, and his ancestors were pleased at the position of favor he had attained. So the kiln of his dreams had become a reality. It was rectangular in shape and fired through an opening in the front at the top. The flames passed uniformly through the setting and out to the chimney through an opening at the bottom of the back wall.

His friends at first attempted to discourage him in the plan, saying that the fire spirits could not be made to go down to get out of the kiln, but he had forced them to bow to his wishes, and now his friends came to copy the design. He had devised a means of controlling the draft such that when the firing was finished he could close it completely and seal the elusive color within until after the contents of the kiln had become quite black and the air spirits were powerless to destroy the work of the spirits of smoke.

The ancient Ching would not have understood the terms, oxidation, reduction, and transmutation, but he did know as a result of his experiments that, when he put a few handfuls of charcoal in the sagger with an especially fine bowl for the Emperor's study and sealed the sagger tightly with glaze, the finest ching blue, the despair of his contemporaries, would result from the firing. Without it, he would obtain the more usual celadon.

Ching was successful now, but thinking back, he wondered whether he would have had the courage to go on had he foreseen the years of difficulties ahead—years of anxiously awaiting the outcome of experimental firings that would determine further procedure.

He recalled the thrill of opening his first kiln, a thrill he experienced as keenly today. The anxious moments of waiting had taught him patience.

Patience while the unloaders, girded in water-soaked

matting with great pads of it wrapped around their hands and feet, ran into the still hot kiln, hastily picking up the saggers and rushing out to set them down gingerly in the open to cool.

Then when the saggers were broken open—the disappointment when a carefully planned experiment fell short of success or when a beautiful shape had become a waster through failure of a stilt.

These and many other disappointments had chastened Ching and taught him how to appreciate truly the beautiful color, form, and texture of the rare gifts which also came in consolation for the failures.

How vividly events in those years of preparation stood out!

At Yüeh, he had his fundamental training, learned to throw with feeling and etch with imagination and freedom. It was there he learned that Wood ash in the glaze and sealing the saggers tightly during firing was the secret of the subtle color of the ware.

But it was for his skill and ability in executing so boldly his highly simplified designs that he was invited to the district where the excellent Ting Yao was being made. He worked long and earnestly there, and his etching seemed to be inspired.

(Some of the finest examples of Ting design still in existence today are the work of the ancient Ching. Recently, while examining some of the best collections of oriental art in England and on the Continent, I found that by picking out the finest piece of Ting in each collection I had isolated a group in which nearly every piece was undoubtedly his work.)

Some of his best work, however, was done during a brief period at the old Ying Ching kilns where it occurred to him that the addition of some of the glaze material to the white body paste might produce a delicate ware that would transmit light. It did, and in recognition of this achievement, he was appointed to a position of authority.

In this capacity, Ching became a master at the art of imparting depth to the quality of his glazes.

In his celadons, he learned the value of a dark body to accomplish this.

He learned to treat his most delicate pieces in a special way. He could make them thinner than his contemporaries because he attempted no thinning until after they had a very light firing. This gave strength to the body for the scraping process and for the heavy glaze coating which followed. The glaze often became, through repeated dippings and firings, of a thickness greater than the body itself, so that starting with a dark body the quality of depth thereby imparted made the piece seem to be bodiless and to be composed entirely of glaze.

One day a potter from another district showed him a bowl of a heavy ware with a coarse buff body and a cloudy lavender blue glaze that greatly excited his curiosity.

He learned its source and immediately set forth to study its manufacture.

This was the kiln of Chün Chou, and there he learned to achieve his fine transmutation effects. He learned to develop a beautiful ching blue from reduced iron in the glaze quite different from the typical oxidized copper Chün.

This was the blue ching color that had so greatly pleased the Emperor and for which he had been made Director of the Imperial Kilns.

As Ching related these events, young Chang had listened eagerly and attentively.

A new life was opening to him. He was to undertake the more pressing responsibilities in the operation of the kilns, leaving the ancient Ching free to carry on his further researches.

Years later, he and his younger brother were destined to make famous the ware of Ko and Lung Ch'üan.

As he talked, Old Ching had been feeling between his fingers the texture of the glaze on the last trial piece drawn from the kiln that day. He handed it to Chang and told him to skip it over the surface of the pool. Chang did, and as it skipped far across to the opposite shore the ripples gently rocked the lotus pads and the goldfish flashed in the shattered reflection of the white jade moon.

That trial piece was unearthed, during a search of the vicinity of the old palace grounds, in China last summer by a friend of mine. I received it as a gift from him a few months ago in England.

I felt sure it had a story to tell and I hope I have told it creditably.

Explanatory Note

During the past year I have been assisting James M. Plumer of the University of Michigan in a study of kilnsite material brought back by him from China, where he made his notable discovery of the point of origin of the famous ware of Yüeh which was manufactured on such a large scale and so widely distributed a thousand years ago.

Further investigation led to a trip this summer, by Professor Plumer and me, sponsored by the University, to England and the Continent to examine examples of this ware in museums and private collections.

Many technical data have been accumulated as a result of investigations carried on in the laboratories of the Ford Motor Company, which has coöperated in extending the use of its research facilities and my time for this purpose.

On this occasion, however, rather than list facts and figures, I have written a short story in which an attempt has been made at reconstruction of pottery processes as they might have been carried on at the remote time when this little-known ware was made.

In telling the story, I have taken certain liberties with the chronology of the Sung kilns, and many of the reconstructions are pure fiction. There is, however, much of fact and much more well within the realm of possibility, but the story was written principally for entertainment and not with any intention of instigating controversy.

Ford Motor Company
Dearborn, Michigan

NEW WINE IN OLD BOTTLES—FIRECLAY PORCELAIN SANITARY WARE

By Albert C. Gerber

Few industries can point with greater legitimate pride to their developments of the past twenty-five years than the vitreous china sanitary-ware industry. The advances in technique, equipment, and design have been sensational. Small wonder then, that in this forward surge of the vitreous china branch, other branches of the sanitary-ware industry have lagged somewhat in this march of progress.

One of these branches recently to fall in line with a modern technique is the fireclay sanitary-ware industry. Important historically, as the progenitor of all types of sanitary ware, this industry continues to command a substantial interest in the sanitary-ware market.

Its beginnings go back forty or more years to the arrival in the Trenton, N. J., district of a group of Scotchmen from the environs of Glasgow, who brought with them their engobes and glazes and their manufacturing methods. Forming was done exclusively by hand pressing of comparatively coarse grog bodies. As a result, the outstanding feature of design was a simple massiveness.

About twenty years ago, the introduction of casting had the effect of reducing some of the dimensions of these early originals. Extremely heavy sections, it was soon learned led to casting difficulties. Up to about a year ago, however, the plumber installing a fireclay sanitary-ware fixture had a lifting problem, particularly a large fixture. Within the past year and a half, there has appeared on the market a new type of fireclay sanitary ware which has torn a page from the book of modern streamline lightweight design.

Having in mind the maximum strains to which any of these fixtures would be put, it was decided to reduce wall thicknesses from $1^1/_2$ to $^5/_8$ inch. Substantial rolls had to be maintained, both to sustain the piece in firing and for the sake of appearance. This virtually meant hollow rolls, and hollow rolls meant drain casting, a distinct innovation in the manufacture of fireclay sanitary ware.

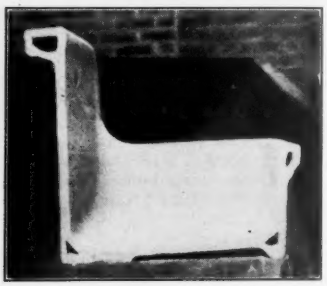

FIG. 1.

After much experimenting, the details involved in manipulating a fireclay casting body, to solid-cast and drain-cast in the same mold, were worked out. Fortunately, it was found possible to lower the casting viscosity sufficiently to permit draining without increasing the water content materially, the latter remaining at about 22%. The average grog fineness was reduced, partially to produce a closer-grained texture and partially to avoid settling. It was found that one of the first requisites to success was exact timing of the various casting operations. With the old method, the casting interval was 15 to 18 hours; the new-method casting interval varies between $2^1/_2$ and 6 hours, depending upon the piece, the condition of the mold, and the weather.

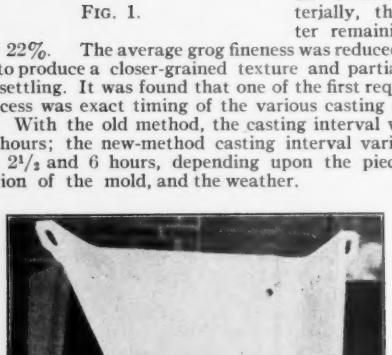

FIG. 2.

Depending, of course, on the individual piece, this method of manufacture permits weight reductions of as much as 40%.

In connection with this new method of manufacture, the problem of glaze fit is interesting. Obviously, it is important, with all bodies of this type, to have the glaze come from the kiln under a maximum compression. On ordinary solid castware, this frequently invites the phenomenon of "shivering," where the grip of glaze and engobe to the body is not equal to the force of compression and, as a result, the glaze is pushed off at the edges. Repeated tests have demonstrated that much higher compression can be set up on drain castware before the glaze lets go. Whatever the actual cause, the inside surface, which is unglazed, offers just enough release to this compressive force to prevent damage to the glaze.

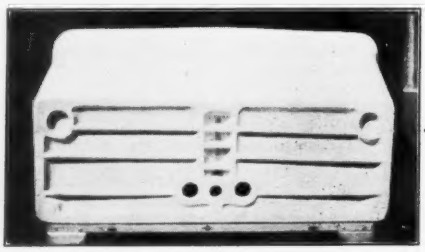

FIG. 3.

Another possibility, of course, may be that this is simply a case of greater cohesion of slip and glaze to this type of body (and greater cohesion of the body itself) than the shear exerted at the edges, with the result that the glazed surface remains intact.

As to hydration expansion and the problem of delayed crazing, the greater vitrification of these bodies serves to reduce crazing. There is no question, however, that the drain cast method also favors resistance to delayed crazing. Identical samples, except that one is cast solid and the other drain cast, coated with exactly the same engobe and the same glaze and given identical autoclave treatment, will always show an improved fit of glaze on the sample prepared by the drain cast method.

This entire development has been an interesting illustration of the advantages to be derived from the application of functional design. Originally intended to improve the ware only from a merchandizing point of view, it was found that a valuable by-product of the new design and method was an important technological improvement.

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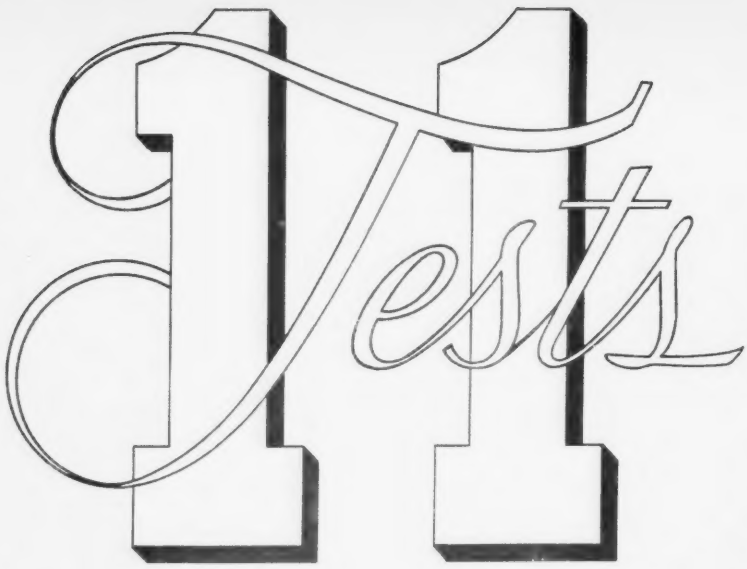

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